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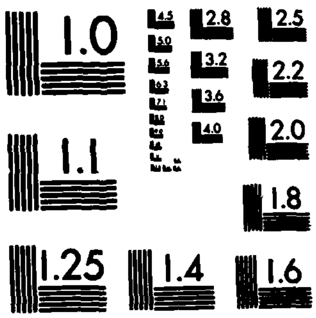

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PHASE III AND FINAL REPORT

FOR
HIGH-RELIABILITY, LOW-COST INTEGRATED CIRCUITS

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For

DEPARTMENT OF THE NAVY
NAVAL ELECTRONICS SYSTEMS COMMAND
Washington, D.C.

Contract No. N00039-76-C-0240
Project No. 62762N
Subproject No. XF54586
Task No. 002

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SECTION I

ABSTRACT

The objective of Phase III of this investigation was to demonstrate the reliability of the integrated circuits fabricated in Phase II according to the processes developed in Phase I (see Phase I and Phase II Final Development Reports for High-Reliability, Low-Cost Integrated Circuits, Contract No. N00039-76-C-0240). Devices were evaluated on the basis of a variety of life and enviromental tests and the data recorded on magnetic tape for later retrieval and analysis. Computer software programs were developed to allow the data to be presented in a number of ways for evaluation and to allow the calculation of failure rates.

ACKNOWLEDGMENT

Support for this program was provided the RCA Solid State Division by the Naval Electronics Systems Command, Electronics Technology Division, ELEX 304, Washington, D.C. Technical direction was provided by the Naval Ocean Systems Center, Advanced Applications Division, Code 923, San Diego, California.

SECTION II

INTRODUCTION

The objective of this program was to investigate alternate approaches to MIL-M-38510 for fabricating high-reliability integrated circuits at low cost. Emphasis was on adapting existing technology to industry mainstream products to achieve a semiconductor reliability that would meet military requirements without a severe cost penalty.

The approach to achievement of the goals of the program involved the integration and application of existing sealed-chip integrated-circuit processing with automated plastic packaging. The program was carried out in three phases.

A. Phase I

1. Process Feasibility - The required photomasks were generated using existing masks to the maximum extent possible. Then, small quantities of each device type were fabricated to assure that the masks and processes were available for the production runs of Phase II. Also, each device type was fabricated using a matrix of carefully varied process parameters whose impact on yields and reliability could be assessed.

2. Process Development - The processes required to fabricate the integrated-circuit types to be produced in Phase II were defined and documented. Silicon nitride passivation and the titanium-platinum-gold metallization system were used to achieve chip hermeticity and a corrosion-free metallization system. In addition, a silicon nitride overcoat layer was applied for protection of the metallization. A series of experiments was completed at each critical processing step to assure repeatability. Real-time indicators and accelerated life tests were

used to assess the effects of process changes on reliability and to measure progress in achieving the required failure rate.

3. Automated Assembly - The technology to be used in Phase II was defined and documented. The effect of assembly process parameters on cost and yield was assessed. Bonding tapes and leadframes compatible with each of the device types were designed and fabricated. A number of devices of each type were assembled using the automated assembly system. Reliability was monitored continually by means of accelerated life tests.

The photomasks, wafer process, and assembly process required to fabricate the integrated-circuit types in the low-cost high-reliability device-fabrication phase were defined and documented, and sample devices of each type were fabricated. Additionally, preliminary reliability data was generated to demonstrate the soundness of the chosen approach.

At this time, the production runs of Phase II were undertaken.

B. Phase II

The low-cost high-reliability device-fabrication phase of the program involved the fabrication of significant quantities of each of the selected integrated-circuit types according to the processes defined in Phase I. Both silicon nitride passivated, titanium-platinum-gold metallized integrated circuits and conventional silicon dioxide passivated, aluminum-metallized integrated circuits were constructed in both plastic and ceramic packages so that a comparison could be made between the new and conventional processes. The utilization of existing equipment and mask sets was demonstrated, and the cost impact of converting to this type of processing estimated. Preliminary reliability testing highlighted two problems areas: copper migration and beam-tape stress. Modifications to the packaging system were made which successfully resolved these problems.

All devices produced in this phase of the program were utilized in Phase III for reliability testing and delivery to the Navy. Finally, the testing facilities for the Phase III program were defined and assembled.

C. <u>Phase III</u>

In Phase III, the reliability of the devices produced in Phase II was demonstrated through operating-life tests, static-life tests, storage-life tests, moisture tests, thermal-cycling and sequence tests. All devices were serialized and data logged prior to the start of the tests and the information stored on magnetic tape. Data was similarly recorded at down periods and at the end of test. Software was generated to format this data in a variety of ways, and from this base the device failure rates were calculated.

SECTION III

ACCOMPLISHMENTS

Data derived from Phase III of the program may be summarized as follows:

- The reliability problems associated with beam-tape design and metallurgy in Phase II were successfully resolved and did not impact Phase III testing.

- The failure rate at +125°C of the HRLC (high-reliability, low-cost) 54S20 low-power Schottky TTL circuit based on all the data available is estimated to be no greater than 0.0081%/1000 hours at 60% confidence to military limits.

- The HRLC CA741 failure rate at +125°C based on accelerated test results is estimated to be no greater than 0.019%/1000 hours at 60% confidence to military limits. The difference between this failure rate and that for the 54S20 is believed to be caused by voltage stress levels (5.5 V for the 54S20 versus 30 V for the CA741.)

- The HRLC CD4012 failure rate at +125°C based on accelerated test results is estimated to be no greater than 0.17%/1000 hours at 60% confidence to military limits.

SECTION IV
DETAILED FACTUAL DATA -- TECHNICAL DISCUSSION

A. Objectives of Phase III

During Phase III of this program to design and develop low-cost high-reliability integrated circuits, the reliability of the parts fabricated in Phase II according to processes developed in Phase I was demonstrated through a predetermined test plan which entailed extended life and environmental tests. Parametric data was taken and recorded at the start of each test, at subsequent down times, and at the termination of the test. All data was stored on magnetic tape and later used to calculate device failure rates.

B. Test Plan

The testing plan for the HRLC program is shown in Figure IV-1. The schedule of down times is shown in Table IV-1. The test plan has four distinct sections: life tests, moisture tests, thermal-cycle tests, and sequence tests. Each test is described and the data reviewed in the following sections. Table IV-2 summarizes the tests performed in Phase III and the test durations.

C. Life and Environmental Tests

1. Operating and Bias-Life Tests

The operating and bias-life tests were based on MIL-STD-883B, Method 1005.2. 125°C operating-life tests were carried out to 5,000 hours on six different plastic-packaged device types. The results are summarized in Table IV-3. Life-test circuits are shown in Figures IV-2 through IV-11.

SCREENED UNITS

LIFE TESTS

Operating Life
CA741, 5420, 54S20, 5470, 5472

Temp (°C)	HRLC DIP
125	150

Operating Life
CD4012

Temp (°C)	HRLC DIP
125	300

STATIC LIFE
CD4012[1], CA741[1], 54S20

Temp (°C)	HRLC DIP	HRLC DIC
150	30	30
175	30	30
200	30	30
225	30	30
250	30	30

STORAGE LIFE
CD4012, CA741, 54S20

Temp (°C)	HRLC DIP	HRLC DIC
150	25	5

MOISTURE TESTS[2]

Bias-Humidity

Conditions	HRLC DIP	HRLC DIC
85°C/85% RH	45	15

Pressure Cooker

Conditions	HRLC DIP	HRLC DIC
15 PSIG	30	10

SALT ATMOSPHERE

Conditions	HRLC DIP	HRLC DIC
MIL 1009.1	20	10

THERMAL-CYCLE TESTS[2]

Thermal Shock

Conditions	HRLC DIP	HRLC DIC
-65°C to 150°C (Liq.-to-Liq.)	20	5

TEMPERATURE CYCLES

Conditions	HRLC DIP	HRLC DIC
-65°C to 150°C (Air-to-Air)	20	5

SEQUENCE TESTS[2]

24-Hour Salt Atmosphere Plus 160-Hour 85°C Static Life

HRLC DIP	HRLC DIC
15	5

50-Cycle -65°C to +150°C Thermal Shock Plus 160-Hour 125°C Operating Life

HRLC DIP	HRLC DIC
20	5

15-Cycle, -65°C to +150°C Thermal Shock Plus 10-Cycle -65°C to ±150°C Temperature Cycle Plus 10-Day Moisture Resistance

HRLC DIP	HRLC DIC
20	10

1. Performed during Phase II.
2. Moisture, Sequence, and Thermal-Cycle tests were conducted on a three-type mix in quantities shown: CA741, CD4012, 54S20.

Fig. IV-1 - Phase III test plan.

Table IV-1 - Schedule of Down Times

Test		Down Time for Electrical Test
Operating Life	125°C	168,1000,2000,5000 Hours
Static Life	150°C	168,500,2000,5000 Hours
Static Life	175°C	168,500,2000,5000 Hours
Static Life	200°C	48,168,250,500,1000,2500 Hours
Static Life	225°C	48,168,250,500,1000,2500 Hours
Static Life	250°C	12,48,96,168,500,1000 Hours
Storage Life	150°C	168,500,2000,5000 Hours
Humidity Bias Life	85°C/85% RH	168,500,1000,2500 5000 Hours
Pressure Cooker	15 PSIG	48,96,200 Hours
Salt Atmosphere		24,96 Hours
Thermal Shock -65°C to 150°C		100,500,1000,2000 Cycles
Temperature Cycle -65°C to 150°C		100,500,1000,2000 Cycles
Sequence Test 1		1,2,3 Cycles
Sequence Test 2		1,2,3 Cycles
Sequence Test 3		1,2,3 Cycles

Note: Sequence tests are as follows:

1. Salt atmosphere plus bias life.
2. Thermal shock plus operating life.
3. Thermal shock plus temperature cycle plus moisture resistance.

Table IV-2 - Phase III Testing (Hours or Cycles Completed)

	CA741	CD4012	5420	5470	5472	54S20
125°C Operating-Life Test - Hrs.	5000	5000	5000	5000	5000	5000
Static-Life Test - Hrs.	NA	NA	NA	NA	NA	
150°C						5000
175°C						4700
200°C						2500
225°C						2500
250°C						1000
150°C Storage-Life Test - Hrs.	5000	5000	NA	NA	NA	5000
85°C/85% RH Bias-Life Test - Hrs.	5000	2500	NA	NA	NA	5000
15 psig Autoclave - Hrs.	200	200	NA	NA	NA	200
Salt Atmosphere - Hrs.	96	96	NA	NA	NA	96
Thermal Shock - Cycles	2000	2000	NA	NA	NA	2000
Temperature Cycle	2000	2000	NA	NA	NA	2000
Salt Atmosphere + 160 Hr., 85°C Static-Life Test - Cycles	3	3	NA	NA	NA	3
Thermal Shock + 160 Hr., 125°C Operating-Life Test - Cycles	3	3	NA	NA	NA	3
Thermal Shock + Temperature Cycle + Moisture Resistance - Cycles	3	3	NA	NA	NA	3

Table IV-3 - 125°C Operating-Life Test Summary

Number of Devices Exceeding Specified Limits
(Mil = Mil 38510/Limits
Comm = Commercial Data Sheet
Inop = Inoperable)

	CA741 N=150			CD4012 N=300			5420 N=150			5470 N=150			5472 N=144			54S20 N=150		
Hours	Mil	Comm	Inop	Mil	Comm	Inop	Mil	Comm	Inop	Mil	Comm	Inop	Mil	Comm	Inop	Mil	Comm	Inop
168	2	2	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1000	0	0	0	13	5(2)	2	0	0	0	0	0	0	1	1	1(5)	0	0	0
2000	0	0	0	2	4(3)	0	1	1	1(4)	0	0	0	0	0	0	0	0	0
2368	-	-	-	1	0	0	-	-	-	-	-	-	-	-	-	-	-	-
5000	1	1	1(1)	2	0	0	0	0	0	0	0	0	2	2	0	0	0	0
Total	3	3	1	22	9	2	1	1	1	0	0	0	3	3	1	0	0	0

Notes:

1. Device #106 burned up on rack. Failure analysis indicates electrical overstress.

2. CD4012 - Five units. All fail at 1000 hrs. #192, 179 and 285 fail I_{SS}. #67 and 84 fail multiple parameters. Device #67 had a Pin 7 to Pin 13 NMOS gate-oxide short. Failure analysis indicates oxide nonuniformity. Device #84 had a Pin 3 to Pin 1 gate-oxide short. Failure analysis indicated electrical overstress. Note: The I_{SS} failures were checked on 4-15-80; the devices recovered.

3. CD4012 - Four units, all fail at 2000 hrs. #18, #141, failed I_{SS}, #206 failed IIH2. #222 failed I_{SS} + multiple.

4. Device #90. Multiple failure. Failure analysis indicates external lead-frame short.

5. Device #100 failed some truth-table functional tests at 1000 hours. Unit recovered after overnight bake at 150°C and was put back on test. Device was operative at all subsequent down times.

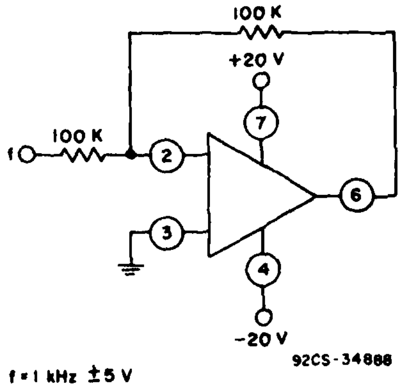


Fig. IV-2 - CA741 125°C operating-life-test circuit.

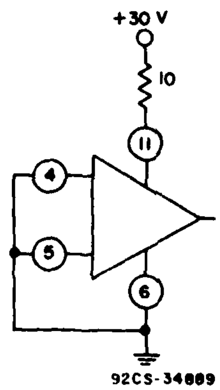


Fig. IV-3 - CA741 250°C bias-life-test circuit.

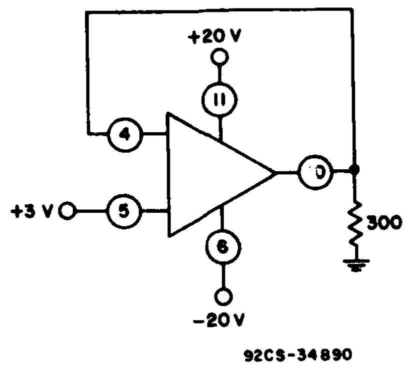


Fig. IV-4 - CA741 bias/humidity-test circuit.

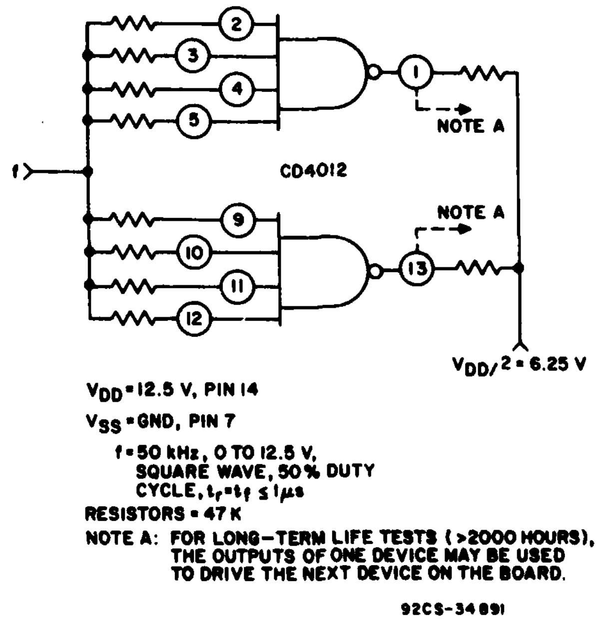


Fig. IV-5 - CD4012 125°C dynamic-life-test circuit. This circuit may also be used for dynamic burn-in at 125°C, 168 hours.

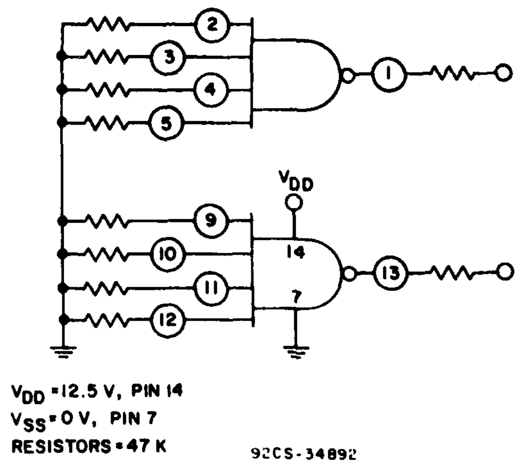


Fig. IV-6 - Circuit used for CD4012 250°C bias life and 85°C/85% R.H. bias/humidity test, inputs low.

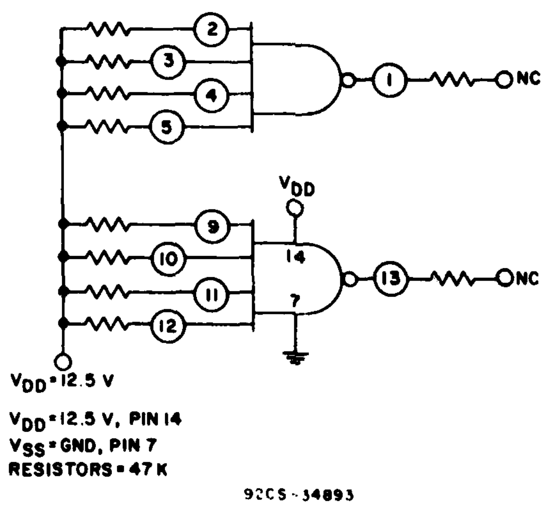


Fig. IV-7 - Circuit used for 250°C bias life and 85°C/85% R.H. bias/humidity test, inputs high.

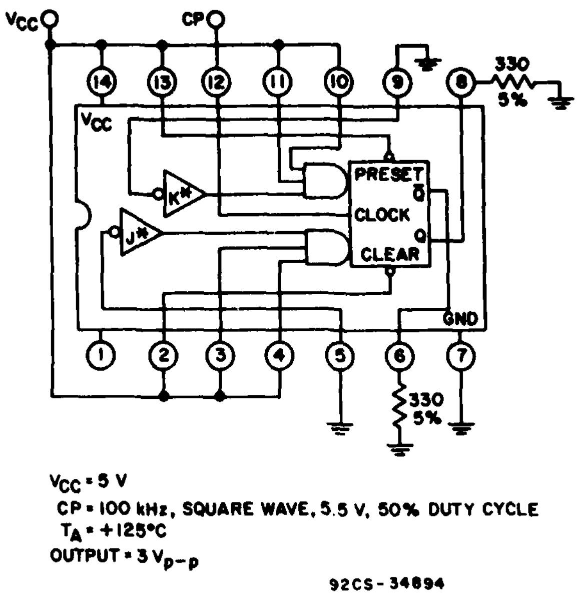


Fig. IV-8 - 5470 125°C operating-life-test circuit.

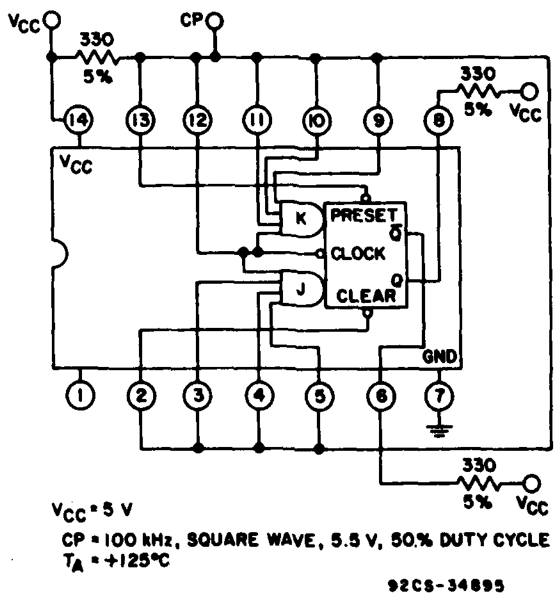


Fig. IV-9 - 5472 125°C operating-life circuit.

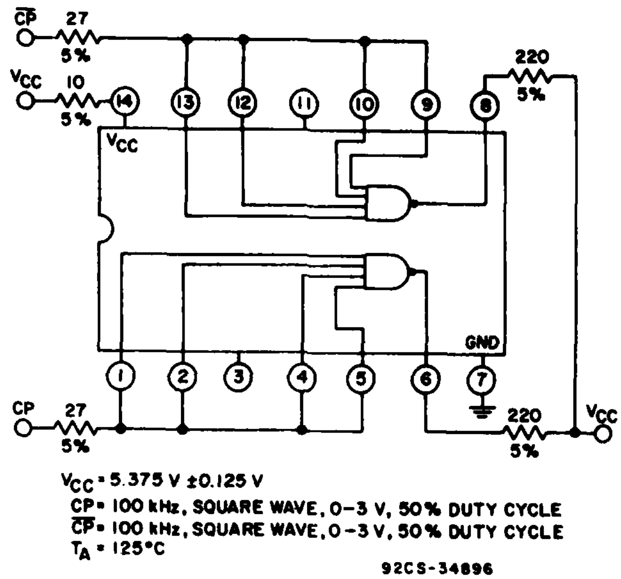


Fig. IV-10 - 54S20 125°C operating-life-test circuit.

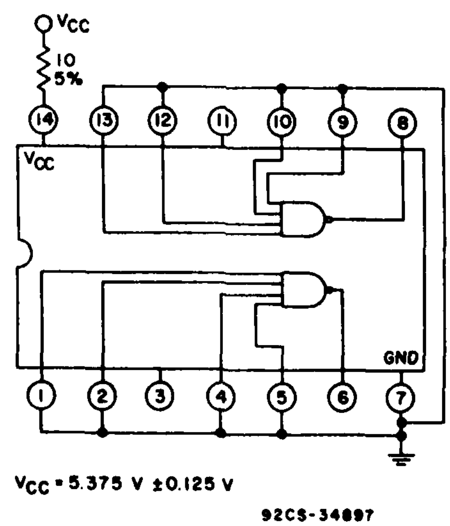


Fig. IV-11 - 54S20 250°C static-burn-in circuit.

a. CA741 - The test sample for the CA741 consisted of 150 devices on 125°C operating-life test. Two early parametric failures occurred at 168 hours. These units recovered after a 48-hour, 150°C bake. The failure mechanism was attributed to mobile ion contamination. A third failure occurred at 5,000 hours, the final down time. Failure analysis indicated electrical overstress. Phase II bias-life tests had few failures from 150°C to 225°C; see Table IV-4. At 250°C, the predominant failure mode was bond-beam breaks. These were corrected before the start of Phase III with a new tape layout.

b. CD4012 - The test sample for the CD4012 consisted of 300 devices on 125°C operating-life test. There were failures to the military limits at each down time. The number of failures decreased dramatically after 2,000 hours. The same phenomenon had occurred in Phase II on 150°C bias life (Table IV-5). In addition, the number of failures on 150°C, 175°C, 200°C, 225°C, and 250°C bias-life tests run in Phase II were relatively independent of temperature.

As previously noted, the military limits on these devices are very severe and may have caused the erratic results. A decision was made to restrict the failure-analysis effort to commercial limit and to inoperative failures, of which there were a total of nine.

c. 5420 - The test sample for the 5420 consisted of 150 devices. One failure occurred at 2,000 hours, and was attributed to a lead-frame short; the short was external to the silicone body. There were no additional failures out to the final down time.

Table IV-4 - CA741 HRLC Accelerated Bias Life at 30V

Number of Devices Exceeding Mil-Std and Commercial Limits at Each Down Time

250°C (N=28)			225°C (N=29)			200°C (N=30)			175°C (N=30)			150°C (N=30)			
Hrs.	Mil	Com	Hrs.	Mil	Com	Hrs.	Mil	Com	Hrs.	Mil	Com	Hrs.	Mil	Com	
2	0	0	2	0	0	2	3	3	8	0	0	8	0	0	Phase II
4	0	0	4	0	0	4	0	0	24	0	0	24	0	0	
8	0	0	8	1	0	8	0	0	168	0	0	168	0	0	
16	0	0	16	0	0	16	0	0	336	0	0	500	0	0	
32	4	3	32	0	0	32	0	0	672	0	0	1000	0	0	
64	3	1	64	0	0	64	0	0	1000	0	0	1500	0	0	
128	6	3	128	0	0	128	0	0	2000	0	0	2000	0	0	
256	13	3	256	1	1	256	1	0	3024	0	0	2500	0	0	Phase III
512	0	3	424	0	0	512	0	0	4000	0	0	4000	0	0	
1500	1	4	1500	0	0	992	0	0	5000	0	0	5000	0	0	
									6024	0	0	7064	0	0	
									10,000	0	0				
Total	27	17		2	1		4	3		0	0		0	0	

Table IV-5 - CD4012 HRLC Accelerated Bias Life at 12.5V

Number of Devices Exceeding Mil-Std and Commercial Limits at Each Down Time

250°C (N=30)			225°C (N=30)			200°C (N=30)			175°C (N=30) (a)			150°C (N=30)			
Hrs.	Mil	Com	Hrs.	Mil	Com	Hrs.	Mil	Com	Hrs.	Mil	Com	Hrs.	Mil	Com	
2	1	0	2	3	0	2	2	0	8	4	1	8	2	0	Phase II
4	1	0	4	2	1	4	1	1	24	0	0	24	2	0	
8	1	0	8	0	0	8	0	0	168	0	0	168	2	0	
16	4	0	16	1	0	16	0	0	336	0	0	500	1	0	
32	2	1	32	3	1	32	1	0	672	0	0	1000	0	0	
64	5	0	64	0	0	64	1	0	1000	0	0	1500	0	0	
128	1	3	128	4	0	128	4	1	1344	0	0	1836	0	0	
256	1	2	256	3	0	256	5	0	1680	1	0	3012	0	0	Phase III
424	1	0	424	0	4	424	3	2	2000	0	0	4012	0	0	
880	4	4	880	1	2	880	0	2	2520	0	0	6052	0	0	
1048	0	0	1500	1	1	1336	0	1	3020	2	0	8112	0	0	
									4004	1	1	10012	0	0	
									6020	0	0	12028	0	0	
Total	21	10		18	9		17	7		8	2		8	0	

(a) 7 units removed: 3 broken pins, 4 V_{SS} diode

d. 5470 - The test sample for the 5470 consisted of 150 devices. There were no failures out to 5,000 hours.

e. 5472 - The test sample for the 5472 consisted of 144 devices. One device failed some truth-table functional tests at 1,000 hours. This unit recovered after an overnight bake at 150°C and was put back on test. The device passed at all subsequent down times. There were two additional parametric failures at the 5,000-hour down time.

f. 54S20 - The 125°C life-test sample for the 54S20 consisted of 150 devices. There were no failures on this test out to 5,000 hours. In addition, bias-life tests were run at five different temperatures for both plastic and ceramic devices. At each temperature, 30 plastic devices and 30 ceramic devices were tested. On the 150°C, 175°C, 200°C, and 225°C tests there were no failures in either the plastic or ceramic-packaged devices (see Tables IV-6 and IV-7.) However, on the 225°C test, the plastic cell had four military limit failures. All four occurred at the 2,500-hour down time. The ceramic cell had one military limit failure on this test. It also occurred at the 2,500-hour down time. On the 250°C test, there were four military limit failures at 12 hours. An additional military limit failure occurred at 500 hours. There were no additional failures through the final 1,000-hour down time. Failure analysis on all five devices indicated Schottky-diode leakage. There were no failures in the ceramic-packaged devices on the 250°C test.

g. Failure-Rate Calculations - Failure rates for the various integrated circuits based on 125°C operating-life testing are shown in Table IV-8. As noted in the original contract proposal, 40-million device-hours with one failure would be required to meet the stated goal of 0.005%/1,000 hours. The difficulty of this goal is demonstrated in the case of the 5420, the 5470, and the 54S20, for which no failures occurred in the course of the 5,000-hour life test; however, the calculated failure rate is 0.12%/1000 hours.

Table IV-6 -54S20 HRLC Accelerated Bias Life at 5.5V

Number of Devices Exceeding Specified Limits at Each Down Time

250°C (N=30)			225°C (N=30)			200°C (N=30)			175°C (N=30)			150°C (N=30)		
Hrs.	Mil	Inop	Hrs.	Mil	Inop	Hrs.	Mil	Inop	Hrs.	Mil	Inop	Hrs.	Mil	Inop
12	4*	0	48	0	0	48	0	0	168	0	0	168	0	0
48	0	0	168	0	0	168	0	0	500	0	0	500	0	0
96	0	0	250	0	0	250	0	0	2000	0	0	2000	0	0
168	0	0	500	0	0	500	0	0	4700	0	0	5000	0	0
500	1*	0	1000	0	0	1000	0	0						
1000	0	0	2500	4	0	2500	0	0						
Total	5	0		4	0		0	0		0	0		0	0

*All 5 devices failed IIH, (for different inputs). The limit is 50 uA and devices vary from 64.9 to 99.6 uA. Failure analysis indicates Schottky diode leakage.

Table IV-7 - 54S20 Ceramic-Packaged Accelerated Bias Life at 5.5V

Number of Devices Exceeding Specified Limits at Each Down Time

250°C (N=30)			225°C (N=30)			200°C (N=30)			175°C (N=30)			150°C (N=30)		
Hrs.	Mil	Inop	Hrs.	Mil	Inop	Hrs.	Mil	Inop	Hrs.	Mil	Inop	Hrs.	Mil	Inop
12	0	0	48	0	0	48	0	0	168	0	0	168	0	0
48	0	0	168	0	0	168	0	0	500	0	0	500	0	0
96	0	0	250	0	0	250	0	0	2000	0	0	2000	0	0
168	0	0	500	0	0	500	0	0	4700	0	0	5000	0	0
500	0	0	1000	0	0	1000	0	0						
1000	0	0	2500	1	0	2500	0	0						
Total	0	0		1	0		0	0		0	0		0	0

Table IV-8 - Failure Rates from 125°C Testing

				No. of Failures (Less Overstress & Mech.)			(%/1000 Hrs. @60% Conf)		
Type	No. of Devices	No. of Hrs.	No. of Device Hrs.	Mil Limit	Comm Limit	Inop	Mil Limit	Comm Limit	Inop
CA741	150	5000	750,000	2	2	0	0.41	0.41	0.12
CD4012	300	5000	1,500,000	21	8	1	1.50	0.62	0.13
5420	150	5000	750,000	0	0	0	0.12	0.12	0.12
5470	150	5000	750,000	0	0	0	0.12	0.12	0.12
5472	150	5000	750,000	3	3	1	0.58	0.58	0.28
54S20	150	5000	750,000	0	0	0	0.12	0.12	0.12

Accelerated life tests at temperatures ranging from 150°C to 250°C were conducted in Phase II and Phase III of the contract on three types to establish an adequate data base on which to predict failure rates. This data is shown in Table IV-9. Failures on the CA741 and CD4012 at 250°C, which were the result of beam-tape breaks which a subsequent redesign rectified, are not included in the failure statistics. As expected, the 54S20 exhibited the lowest failure rate of the three devices. This success is ascribed to the low voltage which is characteristic of the operation of this type of circuit. The predicted failure rate of the CA741 based on 44,700,000 equivalent device hours at 225°C to military limits is 0.019%/1,000 hours. The CMOS part criticized to military limits exhibited a failure rate of 0.17%/1,000 hours. The primary failure indicators were I_{LL}, whose limits were exceeded by 1 to 10 nanoamperes. The failure rate based on commercial limits is predicted to be 0.063%/1,000 hours.

2. <u>150°C Storage-Life Tests</u>

The 150°C storage-life tests are based on MIL-STD-883B, Method 1008.1, Condition C. 150°C storage-life tests were performed on three types to 5,000 hours. Both plastic and ceramic samples were run on each type. The sample size for each type was 30 plastic and 30 ceramic. The results are summarized in Table IV-10.

a. <u>CA741</u> - Storage-life tests on the CA741 started in Phase II and continued in Phase III. Total hours accumulated were 5,000, with no failures in either plastic or ceramic-packaged devices.

b. <u>CD4012</u> - Storage-life tests on the CD4012 started in Phase II and continued in Phase III. Total hours accumulated were 5,000, with no failures in either plastic or ceramic-packaged devices.

Table IV-9 - Accelerated-Life-Test Failures Rates

	Temp.	Device Hrs.	Accel.(1) Factor	Equiv. Device Hr. @125°C	Mil Limit Failures	Comm. Limit Failures	λ (2) Mil Limits	λ (2) Comm Limits
CA741(5)	250°C	42,000	2110	88.6×10^6	27(4)	17(4)		
	225°C	43,500	621	27.0×10^6	2	1		
	200°C	29,760	160	4.8×10^6	4	3		
	175°C	300,000	35.7	10.7×10^6	0	0		
	150°C	211,920	6.64	1.41×10^6	0	0		
	125°C	750,000	1.0	0.75×10^6	2	2		
	Total	-	-	44.7×10^6	8	6	.019	.014
CA4012(5)	250°C	31,440	2110	66.3×10^6	21(4)	10(4)		
	225°C	45,000	621	27.9×10^6	18	9		
	220°C	40,000	160	6.4×10^6	17	7		
	175°C	180,600	35.7	6.4×10^6	8	2		
	150°C	360,840	6.64	2.4×10^6	8	0		
	125°C	1,500,000	1.0	1.5×10^6	21	8		
	Total	-	-	44.6×10^6	72	26	0.17	0.063
54S20	250°C	30,000	2100	63.3×10^6	5	0(3)		
	225°C	75,000	621	46.6×10^6	4	0(3)		
	200°C	75,000	160	12.0×10^6	0	0(3)		
	175°C	141,000	35.7	5.03×10^6	0	0(3)		
	150°C	150,000	6.64	1.00×10^6	0	0(3)		
	125°C	750,000	1.0	0.75×10^6	9	0	0.0081	0.00077(3)
	Total	-	-	128.6×10^6				

1. 1.lev activation energy.
2. %/1000 Hrs. @ 125°C, 60% confidence.
3. Not criticized to commercial limits, inoperatives.
4. Failures due to beam breaks, corrective action implemented in Phase III.
5. Phase II tests.

Table IV-10 - 150°C Storage-Life Test Summary, Number of Devices Exceeding Mil Std. and Commercial Limits

PLASTIC

	CA741* N=30		CD4012* N=30		54S20 N=25	
Hours	Mil	Comm	Mil	Comm	Mil	Comm
168	0	0	0	0	0	-
500	0	0	0	0	0	-
1000	0	0	0	0	0	-
2000	0	0	0	0	0	-
5000	0	0	0	0	0	-
Total	0	0	0	0	0	-

CERAMIC

	CA741* N=30		CD4012* N=30		54S20 N=5	
Hours	Mil	Comm	Mil	Comm	Mil	Comm
168	0	0	0	0	0	-
500	0	0	0	0	0	-
1000	0	0	0	0	0	-
2000	0	0	0	0	0	-
5000	0	0	0	0	0	-
Total	0	0	0	0	0	-

*Phase II devices continued in Phase III.

c. 54S20 - Storage-life tests on the 54S20 were run in Phase III. Total hours accumulated were 5,000, with no failures in either plastic or ceramic-packaged devices.

3. Bias/Humidity-Life Tests

Bias/humidity tests at 85°C and 85% relative humidity were carried out to 5,000 hours on types CA741 and 54S20 and to 2,500 hours on type CD4012. Both plastic and ceramic samples were run on each type. The data for these tests is summarized in Table IV-11.

a. CA741 - The test sample for the type CA741 consisted of twelve plastic and four ceramic devices. The plastic sample experienced two parametric failures, one at 500 hours and one at 1,000 hours. The ceramic cell suffered one inoperative failure at 2,500 hours; the package lost hermeticity and experienced an arc-over at a base-to-emitter junction.

b. CD4012 - The test sample for the type CD4012 consisted of eleven plastic and four ceramic devices. The plastic sample experienced one parametric failure at 500 hours and one at 1,000 hours. At 2,500 hours there were two additional parametric failures and two inoperative failures. There were three parametric failures in the ceramic cell at 500 hours.

c. 54S20 - The test sample for the type 54S20 consisted of eleven plastic and four ceramic devices. There were no failures in either cell.

4. Autoclave Tests

Autoclave tests were carried out at 15 psig to 200 hours on types CA741, CD4012, and 54S20. Both plastic and ceramic groups were run. The data for these tests is summarized in Table IV-12.

Table IV-11 - 85°C/85% R.H. Bias-Life Test Summary

PLASTIC

	CA741 N=12			CD4012 N=11			54S20 N=11		
Hours	Mil	Comm	Inop	Mil	Comm	Inop	Mil	Comm	Inop
168	0	0	0	0	0	0	0	0	0
500	1	1(1)	0	1	0	0	0	0	0
1000	1	1(1)	0	1	1	0	0	0	0
2500	0	0	0	4	3	2(2)	0	0	0
5000	0	0	0				0	0	0
Total	2	2	0	6	4	2	0	0	0

CERAMIC

	CA741 N=4			CD4012 N=4			54S20 N=4		
Hours	Mil	Comm	Inop	Mil	Comm	Inop	Mil	Comm	Inop
168	0	0	0	0	0	0	0	0	0
500	0	0	0	3	0	0	0	0	0
1000	0	0	0	0	0	0	0	0	0
2500	1	1	1(3)	0	0	0	0	0	0
5000	0	0	0	-	-	-	0	0	0
Total	1	1	1	3	0	0	0	0	0

1. Number 153 failed CMRR and -PSRR at 500 hrs. Device recovered after a 4 hr. bake at 150°C. Device was put back up and failed again at 1000 hrs. Number 156 also failed at 1000 hrs. Device failed VIO, IIB and CMRR. Neither unit was baked at 1000 hrs. Both were put back up and run to 5000 hours.
2. One device, #308, recovered after a 150°C bake.
3. Unit #2 arc-over at BE junction. Package lost hermeticity.

Table IV-12 - Autoclave Test Summary (P = 15 PSIG T = 125°C)

PLASTIC

	CA741 N=8			CD4012 N=8			54S20 N=7		
Hours	Mil	Comm	Inop	Mil	Comm	Inop	Mil	Comm	Inop
48	0	0	0	0	0	0	0	0	0
96	0	0	0	0	0	0	0	0	0
200	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0	0	0

CERAMIC

	CA741 N=3			CD4012 N=3			54S20 N=2		
Hours	Mil	Comm	Inop	Mil	Comm	Inop	Mil	Comm	Inop
48	0	0	0	0	0	0	0	0	0
96	0	0	0	0	0	0	0	0	0
200	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0	0	0

a. CA741 - The test sample for the type CA741 consisted of eight plastic and three ceramic devices. There were no failures in either cell.

b. CD4012 - The test sample for the type CD4012 consisted of eight plastic and three ceramic devices. There were no failures in either cell.

c. 54S20 - The test sample for the type 54S20 consisted of seven plastic and two ceramic devices. There were no failures in either cell.

5. Salt-Atmosphere Tests

Salt-atmosphere tests were performed to MIL-STD-883B, Method 1009.2, Condition C, and were carried out to 96 hours on types CA741, CD4012, and 54S20. Both plastic and ceramic groups were run. The data for these tests is summarized in Table IV-13.

a. CA741 - The test sample for the type CA741 consisted of five plastic and three ceramic devices. There were no failures in the plastic cell. The ceramic cell had one parametric failure (device No. 9) at 96 hours. Device leads were scraped, but the unit failed retesting. The leads were then ultrasonically cleaned in a water and detergent solution and scraped at the body of the device (to remove gold contamination between the leads). The device then recovered.

b. CD4012 - The test sample for the type CD4012 consisted of five plastic and two ceramic cells. There were no failures in the plastic cell. The ceramic cell experienced one parametric failure (device No. 10) at 96 hours. Failure analysis is the same as that for the CA741 failure described in the paragraph above.

Table IV-13 - Salt-Atmosphere Test Summary

PLASTIC

Hours	CA741 N=5 Mil	Comm	Inop	CD4012 N=5 Mil	Comm	Inop	54S20 N=5 Mil	Comm	Inop
24	0	0	0	0	0	0	-	0	0
96	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0	0	0

CERAMIC

Hours	CA741 N=3 Mil	Comm	Inop	CD4012 N=2 Mil	Comm	Inop	54S20 N=2 Mil	Comm	Inop
24	0	0	0	0	0	0	0	0	0
96	1	1(1)	0	1	1(2)	0	0	0	0
Total	1	1	0	1	1	0	0	0	0

1. One unit (#9) failed multiple parameters at 96 hours. After scraping leads and retesting, unit still failed. After ultrasonically cleaning leads in water and detergent solution and scraping leads at the body of the device (to remove gold contamination between the leads) the unit recovered.

2. The unit (#10) failed for multiple parameters at 96 hours.

c. 54S20 - The test sample for the type 54S20 consisted of five plastic and two ceramic devices. There were no failures in either cell.

6. Thermal-Shock Tests

Thermal-shock tests were performed at -65°C to +150°C based on MIL-STD-883B, Method 1011.2, Condition C, and run to 2,000 cycles on types CA741, CD4012 and 54S20. The data for these tests is summarized in Table IV-14.

a. CA741 - The test sample for the type CA741 consisted of five plastic and two ceramic devices. There were no failures in either cell.

b. CD4012 - The test sample for the type CD4012 consisted of five plastic and one ceramic device. There were no failures in either cell.

c. 54S20 - The test sample for the type 54S20 consisted of five plastic and one ceramic device. There were no failures in either cell.

7. Temperature-Cycle Tests

Temperature-cycle tests were performed at -65°C to +150°C based on MIL-STD-883B, Method 1010.3, Condition C, and run to 2,000 cycles on types CA741, CD4012, and 54S20. The data for these tests is summarized in Table IV-15.

a. CA741 - The test sample for the type CA741 consisted of five plastic and three ceramic devices. There was one inoperative plastic device at 1,000 cylces. No ceramic devices failed.

Table IV-14 - Thermal-Shock Test Summary

PLASTIC

	CA741 N=5			CD4012 N=5			54S20 N=5		
Cycles	Mil	Comm	Inop	Mil	Comm	Inop	Mil	Comm	Inop
100	0	0	0	0	0	0	0	0	0
500	0	0	0	0	0	0	0	0	0
1000	0	0	0	0	0	0	0	0	0
2000	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0	0	0

CERAMIC

	CA741 N=2			CD4012 N=1			54S20 N=1		
Cycles	Mil	Comm	Inop	Mil	Comm	Inop	Mil	Comm	Inop
100	0	0	0	0	0	0	0	0	0
500	0	0	0	0	0	0	0	0	0
1000	0	0	0	0	0	0	0	0	0
2000	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0	0	0

Table IV-15 - Temperature-Cycle Test Summary

PLASTIC

	CA741			CD4012			54S20		
	N=5			N=5			N=5		
Cycles	Mil	Comm	Inop	Mil	Comm	Inop	Mil	Comm	Inop
100	0	0	0	0	0	0	0	0	0
500	0	0	0	0	0	0	0	0	0
1000	1	1	1(1)	0	0	0	0	0	0
2000	0	0	0	0	0	0	0	0	0
Total	1	1	1	0	0	0	0	0	0

CERAMIC

	CA741			CD4012			54S20		
	N=3			N=1			N=1		
Cycles	Mil	Comm	Inop	Mil	Comm	Inop	Mil	Comm	Inop
100	0	0	0	0	0	0	0	0	0
500	0	0	0	0	0	0	0	0	0
1000	0	0	0	0	0	0	0	0	0
2000	0	0	0	1	0	0	1	0	0
Total	0	0	0	1	0	0	1	0	0

1. Device #112 failed for continuity on Teradyne Test Set. Not verified in failure analysis. Device has been lost.

b. CD4012 - The test sample for the type CD4012 consisted of five plastic and one ceramic device. There were no failures in the plastic cell. The ceramic device was a parametric failure at 2,000 cycles.

c. 54S20 - The test sample for the type 54S20 consisted of five plastic and one ceramic device. There were no failures in the plastic cell. The ceramic device was a parametric failure at 2,000 cycles.

8. Sequence Test No. 1

Sequence test No. 1 consists of 24 hours of salt atmosphere plus 160 hours of 85°C static life. Three complete cycles of this sequence test were run on types CA741, CD4012 and 54S20. The data is summarized in Table IV-16.

a. CA741 - The test sample for the type CA741 consisted of four plastic and two ceramic devices. There were no failures in either group.

b. CD4012 - The test sample for the type CD4012 consisted of four plastic and two ceramic devices. There were no failures in the plastic cell. The ceramic cell experienced one parametric failure at the second cycle.

c. 54S20 - The test sample for the type 54S20 consisted of four plastic and one ceramic device. There were no failures in the plastic cell. The ceramic device was an inoperative failure at the first cycle. The device failed because of metal migration on the lead-frame external to the body of the device.

Table IV-16 - Salt-Atmosphere +85°C

Static-Life-Test Sequence (#1) Summary

PLASTIC

	CA741 N=4			CD4012 N=4			54S20 N=4		
Cycles	Mil	Comm	Inop	Mil	Comm	Inop	Mil	Comm	Inop
1	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0	0	0

CERAMIC

	CA741 N=2			CD4012 N=2			54S20 N=1		
Cycles	Mil	Comm	Inop	Mil	Comm	Inop	Mil	Comm	Inop
1	0	0	0	0	0	0	1	1	1(1)
2	0	0	0	1	0	0			
3	0	0	0	0	0	0			
Total	0	0	0	1	0	0	1	1	1

1. Unit #166 failed due to metal migration on lead frame external to body of device.

9. Sequence Test No. 2

Sequence Test No. 2 consisted of 50 cycles of thermal shock at -65°C to +150°C plus 160 hours of 125°C operating life. Three complete cycles of this sequence test were run on types CA741, CD4012 and 54S20. The data for these tests is summarized in Table IV-17.

a. CA741 - The test sample for the type CA741 consisted of four plastic and two ceramic devices. There were no failures in either group.

b. CD4012 - The test sample for the type CD4012 consisted of five plastic and one ceramic device. There were no failures in either group.

c. 54S20 - The test sample for the type 54S20 consisted of five plastic and one ceramic device. There were no failures in either group.

10. Sequence Test No. 3

Sequence Test No. 3 consisted of fifteen cycles of thermal shock at -65°C to +150°C plus ten cycles of temperature cycling at -65°C to +150°C plus 10 days of moisture-resistance tests. Three complete cycles of this sequence test were run on types CA741, CD4012, and 54S20. Test data is summarized in Table IV-18.

a. CA741 - The test sample for the type CA741 consisted of five plastic and one ceramic device. The plastic cell experienced one parametric failure at the second cycle and one at the third.

b. CD4012 - The test sample for the type CD4012 consisted of three plastic and two ceramic devices. The plastic cell experienced one parametric failure to commercial limits at the third cycle. The device was baked at 150°C for 16 hours. The unit recovered to commerical limits, but still failed military limits. The ceramic cell experienced two parametric failures to military limits at the third cycle.

Table IV-17 - Thermal Shock +125°C

Operating-Life Test Sequence (#2) Summary

PLASTIC

	CA741			CD4012			54S20		
	N=5			N=5			N=5		
Cycles	Mil	Comm	Inop	Mil	Comm	Inop	Mil	Comm	Inop
1	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0	0	0

CERAMIC

	CA741			CD4012			54S20		
	N=2			N=1			N=1		
Cycles	Mil	Comm	Inop	Mil	Comm	Inop	Mil	Comm	Inop
1	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0	0	0

Table IV-18 - Thermal-Shock Temperature-Cycle Moisture-Resistance Test Sequence (#3) Summary

PLASTIC

	CA741			CD4012			54S20		
	N=5			N=3			N=5		
Cycles	Mil	Comm	Inop	Mil	Comm	Inop	Mil	Comm	Inop
1	0	0	0	0	0	0	0	0	0
2	1	1[1]	0	-	-	-	0	0	0
3	1	1[1]	0	1	1[2]	1	0	0	0
Total	2	2	0	1	1	0	0	0	0

CERAMIC

	CA741			CD4012			54S20		
	N=3			N=2			N=2		
Cycles	Mil	Comm	Inop	Mil	Comm	Inop	Mil	Comm	Inop
1	0	0	0	0	0	0	0	0	0
2	0	0	0	-	-	-	0	0	0
3	0	0	0	2	0	0	0	0	0
Total	0	0	0	2	0	0	0	0	0

1. Number 199 failed after 2 cycles for -PSRR and IIB. Device was kept on test. Number 198 failed for multiple parameters after 3 cycles. Number 199 became worse after 3 cycles. Both units were baked at 150°C for 4 hrs. Both recovered.
2. Number 348 failed I_{SS}, IIH2 after 3 cycles. Unit baked at 150°C for 16 hrs. Recovered to commercial limit, but still failed MIL limit.

c. 54S20 - The test sample for the type 54S20 consisted of five plastic and two ceramic devices. There were no failures in either cell.

D. Computerized Data Analysis

1. General

The data collected in Phase III of the program is shown in three different formats in Tables IV-19 and Figures IV-12 and IV-13. The alphanumeric code associated with each set of readings, for example AA50A01, may be read as follows:

1. The first letter represents the test-duration measurement units:
   - A = hours
   - B = cycles for single tests
   - C = cycles for sequence tests

2. The second letter represents the down time:

A = 0 hours	E = 168 hours	I = 2000 hours
B = 24 hours	F = 200 hours	J = 2500 hours
C = 248 hours	G = 500 hours	K = 5000 hours
D = 96 hours	H = 1000 hours	

3. The third position represents the contract phase:
   - 5 = Phase III

4. The fourth-position digit represents the device type:

0 = CA741	3 = 5470
1 = CD4012	4 = 5472
2 = 5420	5 = 54S20

5. The fifth letter represents the test being run:
   - A = 125°C Operating-Life Test
   - H = 85°C/85% R.H. Bias/Humidity Test
   - I = Autoclave
   - J = Salt Atmosphere
   - K = Thermal Shock
   - L = Temperature Cycle
   - M = Sequence Test No. 1
   - N = Sequence Test No. 2
   - P = Sequence Test No. 3

6. The sixth and seventh digits represent the type of package:
   - 01 = plastic
   - 02 = ceramic

The example given, AA50A01 is, then, the data code for the zero hour, Phase III, CA741, 125°C operating-life test. The units are molded in a plastic package.

2. Delta Analysis

Table IV-19 shows the delta analysis on V_{IO} readings of the 125°C operating life test between 0 and 168 hours. The data for all 150 units in the test are shown. This type of information is available for all of the tests and between any two sets of readings on all of the integrated-circuit types.

3. Histogram

An example of a histogram depiction of data is shown in Figure IV-12. The figure presents the zero-hour V_{IO} readings on the CA741, 125°C operating-life test. A similar histogram can be generated for any parameter, for any test on each type.

Table IV-19 - Data Analysis

```
PAGE     1
DATE PRINTED : 06/12/81                              TIME PRINTED : 5.30.
DELTA AT 168HRS
TYPE =CA741
LOT  =AA50A01 OR AE50A01
CHIP =NOT 800 IF DEGC IS 25
TEST =FROM 1 TO 28
DELTA OPTION
  ROW=CHIP
  COL=LOT
  Q  =TVAL AND RANGE AND UNITS AND REJ

TYPE    =CA741
TEST    =      1
```

CHIP	AA50A01	AE50A01	AE50A01 -AA50A01
1	6.000E-02MV	4.000E-02MV	-2.000E-02MV
2	-1.600E-01MV	8.000E-02MV	2.400E-01MV
3	8.600E-01MV	9.100E-01MV	5.000E-02MV
4	-2.000E+00MV	-1.990E+00MV	1.000E-02MV
5	4.600E-01MV	5.700E-01MV	1.100E-01MV
6	1.120E+00MV	1.130E+00MV	9.999E-03MV
7	8.200E-01MV	8.500E-01MV	3.000E-02MV
8	1.590E+00MV	1.470E+00MV	-1.200E-01MV
9	4.300E-01MV	5.700E-01MV	1.400E-01MV
10	1.520E+00MV	1.660E+00MV	1.400E-01MV
11	1.290E+00MV	1.350E+00MV	6.000E-02MV
12	2.200E+00MV	2.320E+00MV	1.200E-01MV
13	2.200E-01MV	3.500E-01MV	1.300E-01MV
14	-1.500E-01MV	0.0 MV	1.500E-01MV
15	1.360E+00MV	1.600E+00MV	2.400E-01MV
16	1.450E+00MV	1.430E+00MV	-2.000E-02MV
17	-1.140E+00MV	-9.900E-01MV	1.500E-01MV
18	1.850E+00MV	2.180E+00MV	3.300E-01MV
19	1.220E+00MV	1.340E+00MV	1.200E-01MV
20	1.150E+00MV	1.140E+00MV	-1.000E-02MV
21	1.980E+00MV	2.200E+00MV	2.200E-01MV
22	-1.000E-01MV	-1.500E-01MV	-5.000E-02MV
23	1.420E+00MV	1.620E+00MV	2.000E-01MV
24	3.800E-01MV	5.200E-01MV	1.400E-01MV
25	1.750E+00MV	1.770E+00MV	2.000E-02MV
26	7.100E-01MV	7.200E-01MV	1.000E-02MV
27	2.200E-01MV	3.300E-01MV	1.100E-01MV
28	5.100E-01MV	7.000E-01MV	1.900E-01MV
29	9.300E-01MV	9.300E-01MV	0.0 MV
30	-1.190E+00MV	-1.170E+00MV	2.000E-02MV
31	-2.000E-02MV	3.000E-02MV	5.000E-02MV
32	-6.500E-01MV	-4.500E-01MV	2.000E-01MV
33	1.300E-01MV	1.900E-01MV	6.000E-02MV
34	1.070E+00MV	1.050E+00MV	-2.000E-02MV
35	1.670E+00MV	1.770E+00MV	1.000E-01MV
36	-3.900E-01MV	-2.000E-01MV	1.900E-01MV
37	2.030E+00MV	2.110E+00MV	8.000E-02MV
38	1.150E+00MV	1.180E+00MV	3.000E-02MV
39	-7.000E-02MV	-1.500E-01MV	-8.000E-02MV
40	1.540E+00MV	1.750E+00MV	2.100E-01MV
41	-1.620E+00MV	-1.530E+00MV	9.000E-02MV
42	-9.700E-01MV	-8.300E-01MV	1.400E-01MV

Table IV-19 - Data Analysis (continued)

PAGE 2

43	-7.700E-01MV	5.400E-01MV	1.310E+00MV
44	-1.250E+00MV	-1.280E+00MV	-3.000E-02MV
45	-2.000E-02MV	-2.800E-01MV	-2.600E-01MV
46	4.400E-01MV	5.200E-01MV	8.000E-02MV
47	1.790E+00MV	1.900E+00MV	1.100E-01MV
48	2.190E+00MV	2.620E+00MV	4.300E-01MV
49	2.800E-01MV	6.300E-01MV	3.500E-01MV
50	8.900E-01MV	1.280E+00MV	3.900E-01MV
51	1.390E+00MV	1.470E+00MV	8.000E-02MV
52	9.400E-01MV	9.900E-01MV	5.000E-02MV
53	7.600E-01MV	8.300E-01MV	7.000E-02MV
54	9.600E-01MV	1.130E+00MV	1.700E-01MV
55	3.900E-01MV	3.800E-01MV	-1.000E-02MV
56	1.430E+00MV	1.410E+00MV	-2.000E-02MV
57	5.500E-01MV	5.700E-01MV	2.000E-02MV
58	1.220E+00MV	1.260E+00MV	4.000E-02MV
59	-6.600E-01MV	-5.900E-01MV	7.000E-02MV
60	1.670E+00MV	1.750E+00MV	8.000E-02MV
61	1.830E+00MV	2.590E+00MV	7.600E-01MV
62	7.500E-01MV	9.300E-01MV	1.800E-01MV
63	1.570E+00MV	1.610E+00MV	4.000E-02MV
64	3.100E-01MV	4.300E-01MV	1.200E-01MV
65	8.700E-01MV	1.210E+00MV	3.400E-01MV
66	9.800E-01MV	1.110E+00MV	1.300E-01MV
67	7.800E-01MV	9.500E-01MV	1.700E-01MV
68	1.990E+00MV	2.090E+00MV	1.000E-01MV
69	1.380E+00MV	1.500E+00MV	1.200E-01MV
70	1.290E+00MV	1.400E+00MV	1.100E-01MV
71	-1.300E-01MV	-6.000E-02MV	7.000E-02MV
72	4.000E-01MV	4.400E-01MV	4.000E-02MV
73	-1.150E+00MV	-1.130E+00MV	2.000E-02MV
74	8.000E-01MV	8.300E-01MV	3.000E-02MV
75	2.800E-01MV	9.900E-01MV	7.100E-01MV
76	9.000E-01MV	1.100E+00MV	2.000E-01MV
77	7.300E-01MV	1.350E+00MV	6.200E-01MV
78	2.200E-01MV	2.400E-01MV	2.000E-02MV
79	1.190E+00MV	1.240E+00MV	5.000E-02MV
80	1.210E+00MV	1.880E+00MV	6.700E-01MV
81	1.960E+00MV	2.070E+00MV	1.100E-01MV
82	7.600E-01MV	8.700E-01MV	1.100E-01MV
83	6.300E-01MV	5.900E-01MV	-4.000E-02MV
84	1.160E+00MV	1.290E+00MV	1.300E-01MV
85	9.800E-01MV	1.470E+00MV	4.900E-01MV
86	7.300E-01MV	8.600E-01MV	1.300E-01MV
87	2.100E-01MV	3.200E-01MV	1.100E-01MV
88	-1.150E+00MV	-1.090E+00MV	6.000E-02MV
89	6.000E-01MV	4.490E+00MVF	3.890E+00MVF
90	8.700E-01MV	9.900E-01MV	1.200E-01MV
91	9.400E-01MV	1.000E+00MV	6.000E-02MV
92	4.200E-01MV	4.000E-01MV	-2.000E-02MV
93	8.800E-01MV	9.100E-01MV	3.000E-02MV
94	1.590E+00MV	1.690E+00MV	1.000E-01MV
95	9.900E-01MV	1.030E+00MV	4.000E-02MV
96	2.500E-01MV	6.300E-01MV	3.800E-01MV
97	7.600E-01MV	8.300E-01MV	7.000E-02MV
98	1.210E+00MV	1.310E+00MV	1.000E-01MV
99	7.600E-01MV	8.600E-01MV	1.000E-01MV
100	5.100E-01MV	5.900E-01MV	8.000E-02MV

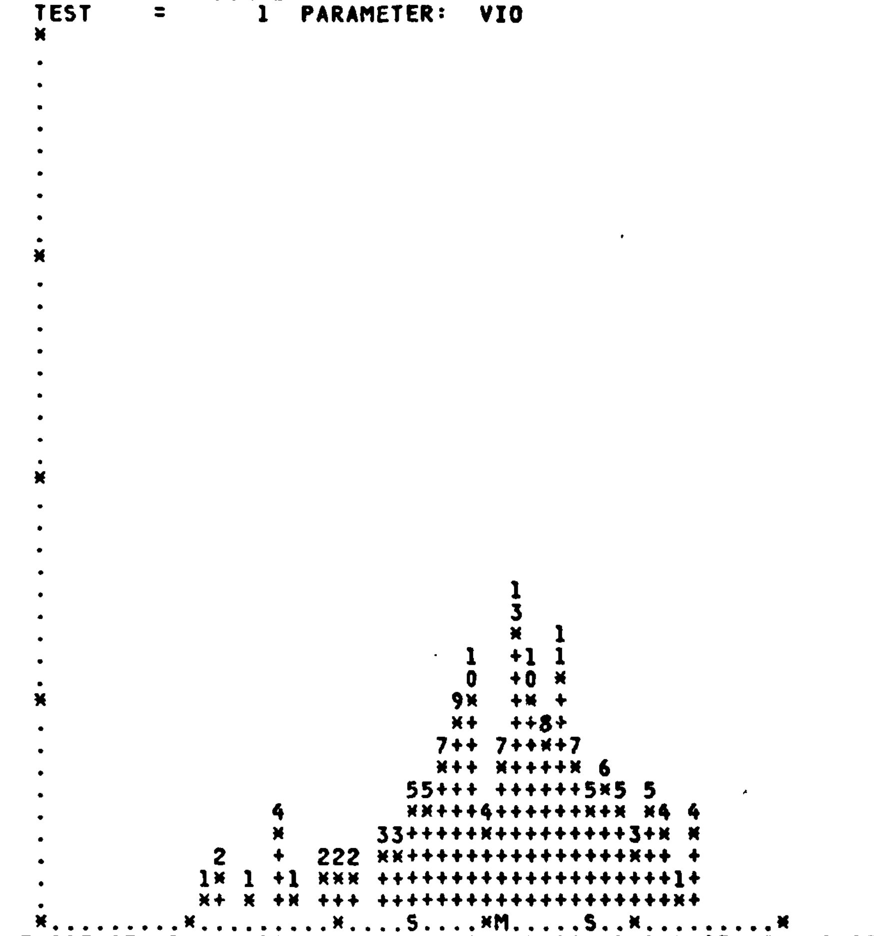
Table IV-19 - Data Analysis (continued)

PAGE 3

101	9.000E-01MV	9.100E-01MV	1.000E-02MV
102	3.300E-01MV	6.500E-01MV	3.200E-01MV
103	1.490E+00MV	1.610E+00MV	1.200E-01MV
104	1.150E+00MV	1.210E+00MV	6.000E-02MV
105	0.0 MV	3.000E-02MV	3.000E-02MV
106	-1.110E+00MV	-8.900E-01MV	2.200E-01MV
107	1.400E-01MV	2.700E-01MV	1.300E-01MV
108	1.290E+00MV	1.450E+00MV	1.600E-01MV
109	4.200E-01MV	4.900E-01MV	7.000E-02MV
110	1.010E+00MV	1.150E+00MV	1.400E-01MV
111	6.300E-01MV	7.900E-01MV	1.600E-01MV
112	8.300E-01MV	9.700E-01MV	1.400E-01MV
113	1.630E+00MV	1.800E+00MV	1.700E-01MV
114	1.900E+00MV	2.050E+00MV	1.500E-01MV
115	1.100E+00MV	1.400E+00MV	3.000E-01MV
116	1.990E+00MV	2.100E+00MV	1.100E-01MV
117	-6.500E-01MV	-5.200E-01MV	1.300E-01MV
118	2.000E-02MV	1.200E-01MV	1.000E-01MV
119	1.160E+00MV	1.270E+00MV	1.100E-01MV
120	7.000E-02MV	2.000E-01MV	1.300E-01MV
121	-4.900E-01MV	-4.700E-01MV	2.000E-02MV
122	9.900E-01MV	1.080E+00MV	9.000E-02MV
123	1.030E+00MV	1.190E+00MV	1.600E-01MV
124	1.720E+00MV	1.840E+00MV	1.200E-01MV
125	1.110E+00MV	1.340E+00MV	2.300E-01MV
126	2.200E-01MV	2.800E-01MV	6.000E-02MV
127	-1.670E+00MV	-1.600E+00MV	7.000E-02MV
128	1.790E+00MV	1.950E+00MV	1.600E-01MV
129	2.700E-01MV	4.400E-01MV	1.700E-01MV
130	6.300E-01MV	7.000E-01MV	7.000E-02MV
131	3.100E-01MV	3.500E-01MV	4.000E-02MV
132	1.050E+00MV	1.220E+00MV	1.700E-01MV
133	7.000E-01MV	8.300E-01MV	1.300E-01MV
134	7.100E-01MV	9.100E-01MV	2.000E-01MV
135	2.500E-01MV	4.400E-01MV	1.900E-01MV
136	1.440E+00MV	1.580E+00MV	1.400E-01MV
137	7.700E-01MV	8.700E-01MV	1.000E-01MV
138	4.100E-01MV	6.100E-01MV	2.000E-01MV
139	5.900E-01MV	6.500E-01MV	6.000E-02MV
140	2.190E+00MV	2.310E+00MV	1.200E-01MV
141	-2.800E-01MV	-2.100E-01MV	7.000E-02MV
142	-1.500E-01MV	-7.000E-02MV	8.000E-02MV
143	2.000E-02MV	1.500E-01MV	1.300E-01MV
144	1.820E+00MV	1.930E+00MV	1.100E-01MV
145	4.600E-01MV	5.700E-01MV	1.100E-01MV
146	1.190E+00MV	1.340E+00MV	1.500E-01MV
147	-2.900E-01MV	-1.900E-01MV	1.000E-01MV
148	1.470E+00MV	1.600E+00MV	1.300E-01MV
149	7.600E-01MV	8.200E-01MV	6.000E-02MV
150	2.600E-01MV	3.800E-01MV	1.200E-01MV

COUNT	1.500E+02	1.500E+02	1.500E+02
MEAN	6.778E-01MV	8.349E-01MV	1.571E-01MV
SIGMA	8.484E-01MV	9.230E-01MV	3.495E-01MV
VARIANCE	7.198E-01	8.519E-01	1.221E-01
COEF VAR	1.252E+02	1.105E+02	2.224E+02
STD SKEW	-6.722E-01	-1.936E-01	8.439E+00
MIN VAL	-2.000E+00MV	-1.990E+00MV	-2.600E-01MV
MAX VAL	2.200E+00MV	4.490E+00MV	3.890E+00MV
MEAN+S	1.526E+00MV	1.758E+00MV	5.066E-01MV
MEAN-S	-1.706E-01MV	-8.806E-02MV	-1.924E-01MV
SKEW PT	2.222E-01MV	6.733E-01MV	1.483E+00MV

```
SUMMARY DATA HISTOGRAM:
   DATE PRINTED : 07/09/81                          TIME PRINTED : 3.37.58
  VIO(T1) HISTOGRAM
  FOR TYPE =CA741
  FOR LOT  =AA50A01 OR AE50A01 OR AH50A01 OR AI50A01 OR AK50A01
  FOR TEST =1 IF DEGC IS 25 IF SUMID IS VIOTREND
                  TYPE     = CA741
                  LOT      = AA50A01
                  TEST     =       1  PARAMETER:  VIO
```




```
SAMPLE SIZE:  150 PLOTTED:  150 BELOW:     0 ABOVE:     0 COUNT PER +:  1
CELL WIDTH: 1.20E-04 MIN VAL:-2.000E-03 MAX VAL: 2.200E-03  UNITS: V
MEAN: 6.778E-04 MEDIAN: 7.600E-04 17% POINT: -2.000E-05 84% POINT: 1.490E-03
```

Fig. IV-12 - Summary data histogram.

4. Trend Analysis

A trend analysis for V_{IO} on the CA741, 125°C operating-life test is shown in Figure IV-13. The down periods represented are 0, 168, 1,000, 2,000, and 5,000 hours. The median values are represented by an X and the length of the vertical lines is the 17% to 84% range. This type of chart shows the parametric shifts over the course of the tests and can be generated for any parameter on each type on each test.

DATE PRINTED : 07/18/81 TIME PRINTED : 3.37.18
VIO(T1) VS TIME
TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND
LOT =AA50A01 OR AE50A01 OR AH50A01 OR AI50A01 OR AK50A01
Y=MED OR 17% OR 84%

TREND PLOT FOR: TYPE = CA741
TEST = 1 PARAMETER: VIO
LEGEND: /MED =X/17% =|/84% =|/
CELL WIDTH: 1.50E-04 MULTIPLE: >

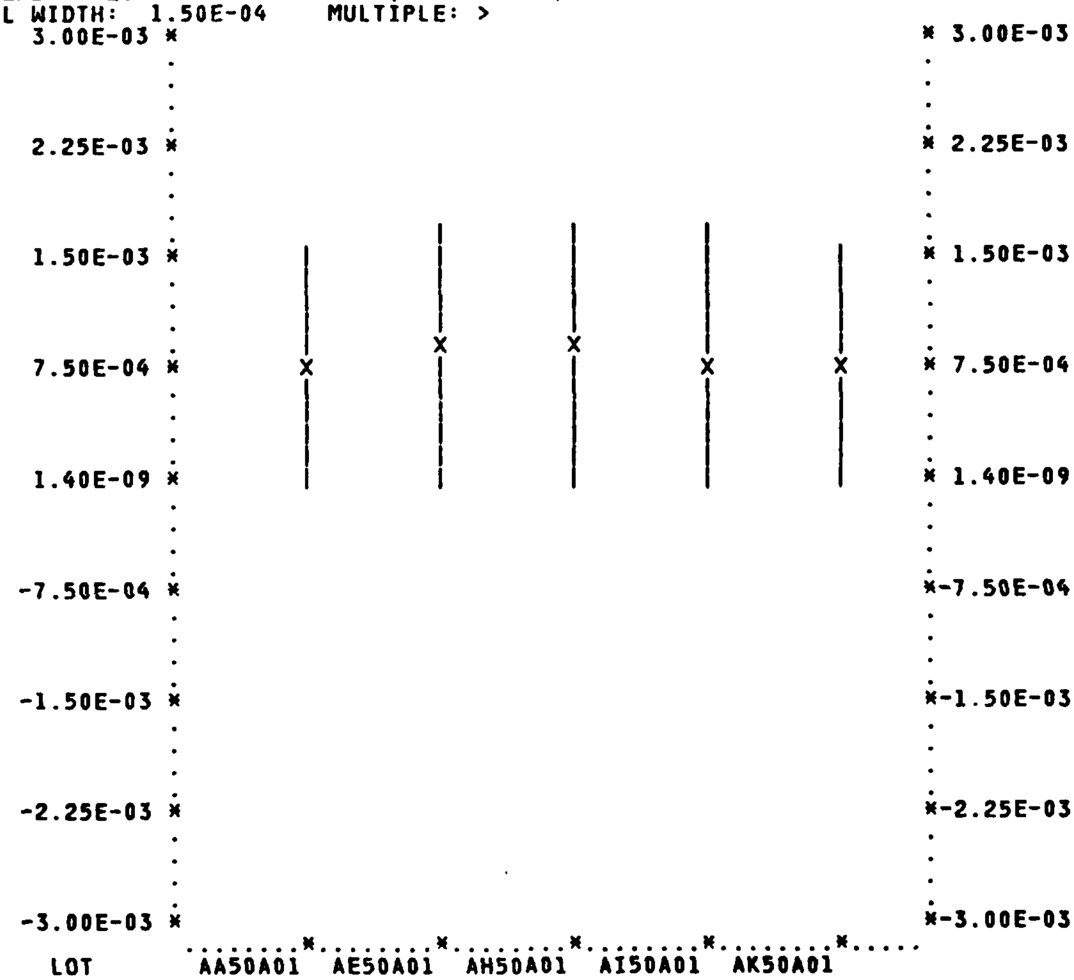


Fig. IV-13 - Trend analysis.

```
DATE PRINTED : 07/18/81                               TIME PRINTED : 3.37.18
VIO(T1) VS TIME
TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND
LOT  =AA50A01 OR AE50A01 OR AH50A01 OR AI50A01 OR AK50A01
    Y=MED OR 17% OR 84%

TREND PLOT FOR: TYPE     = CA741
                TEST     =       2
LEGEND: /MED      =X/17%     =|/84%     =|/
CELL WIDTH:  1.00E-04    MULTIPLE: >
```

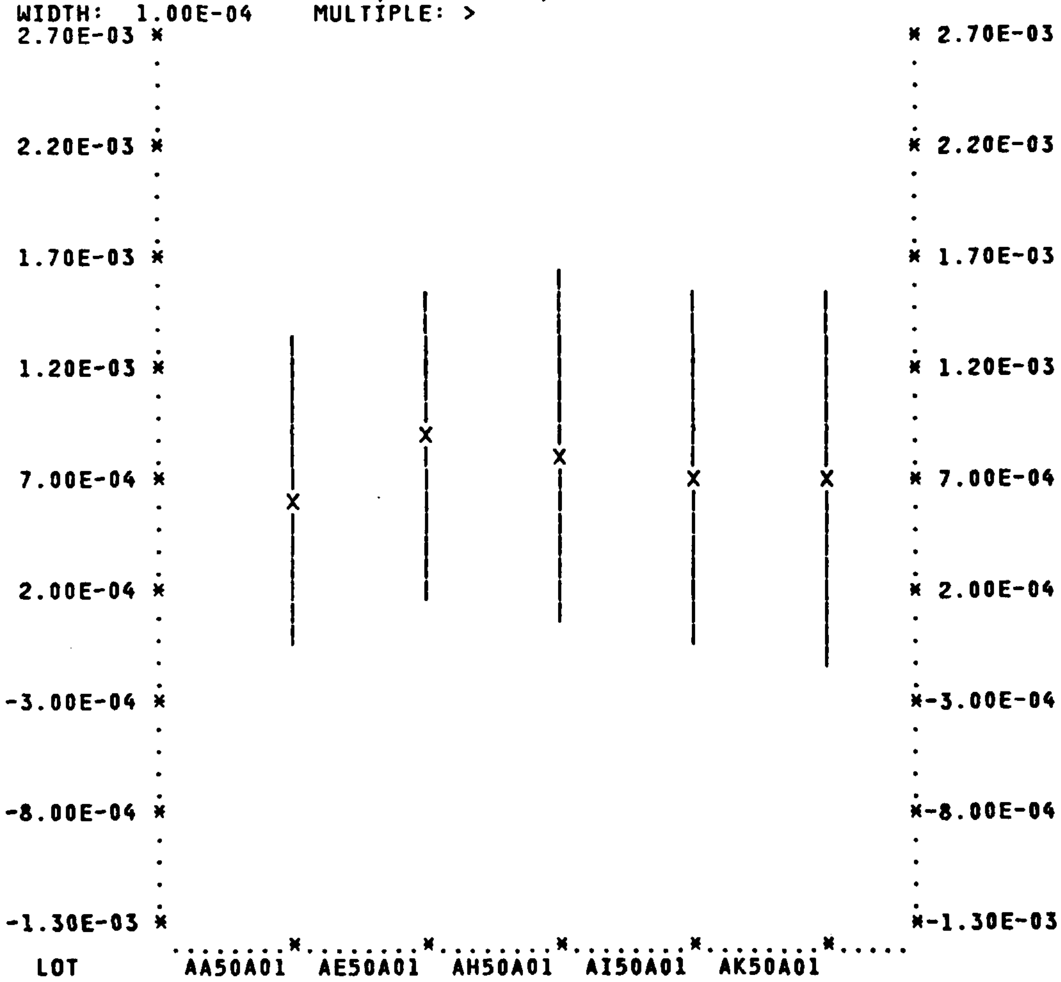


Fig. IV-13 - Trend analysis (continued).

DATE PRINTED : 07/18/81 TIME PRINTED : 3.37.18
VIO(T1) VS TIME
TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND
LOT =AA50A01 OR AE50A01 OR AH50A01 OR AI50A01 OR AK50A01
Y=MED OR 17% OR 84%

TREND PLOT FOR: TYPE = CA741
TEST = 3
LEGEND: /MED =X/17% =|/84% =|/
CELL WIDTH: 1.00E-04 MULTIPLE: >

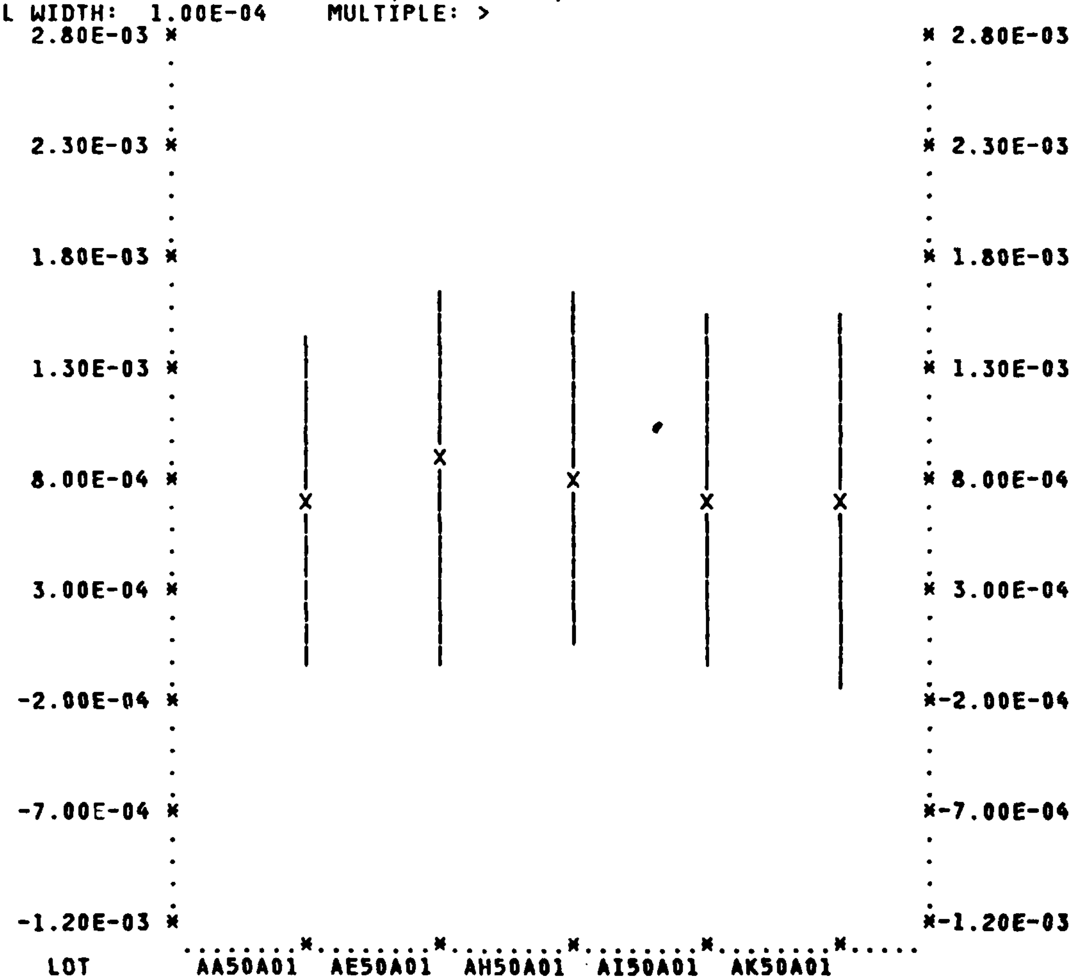


Fig. IV-13 - Trend analysis (continued).

```
DATE PRINTED : 07/18/81                              TIME PRINTED : 3.37.18
VIO(T1) VS TIME
TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND
LOT  =AA50A01 OR AE50A01 OR AH50A01 OR AI50A01 OR AK50A01
    Y=MED OR 17% OR 84%

TREND PLOT FOR: TYPE    = CA741
                TEST    =       4
LEGEND: /MED     =X/17%     =|/84%     =|/
CELL WIDTH:  1.00E-04    MULTIPLE: >
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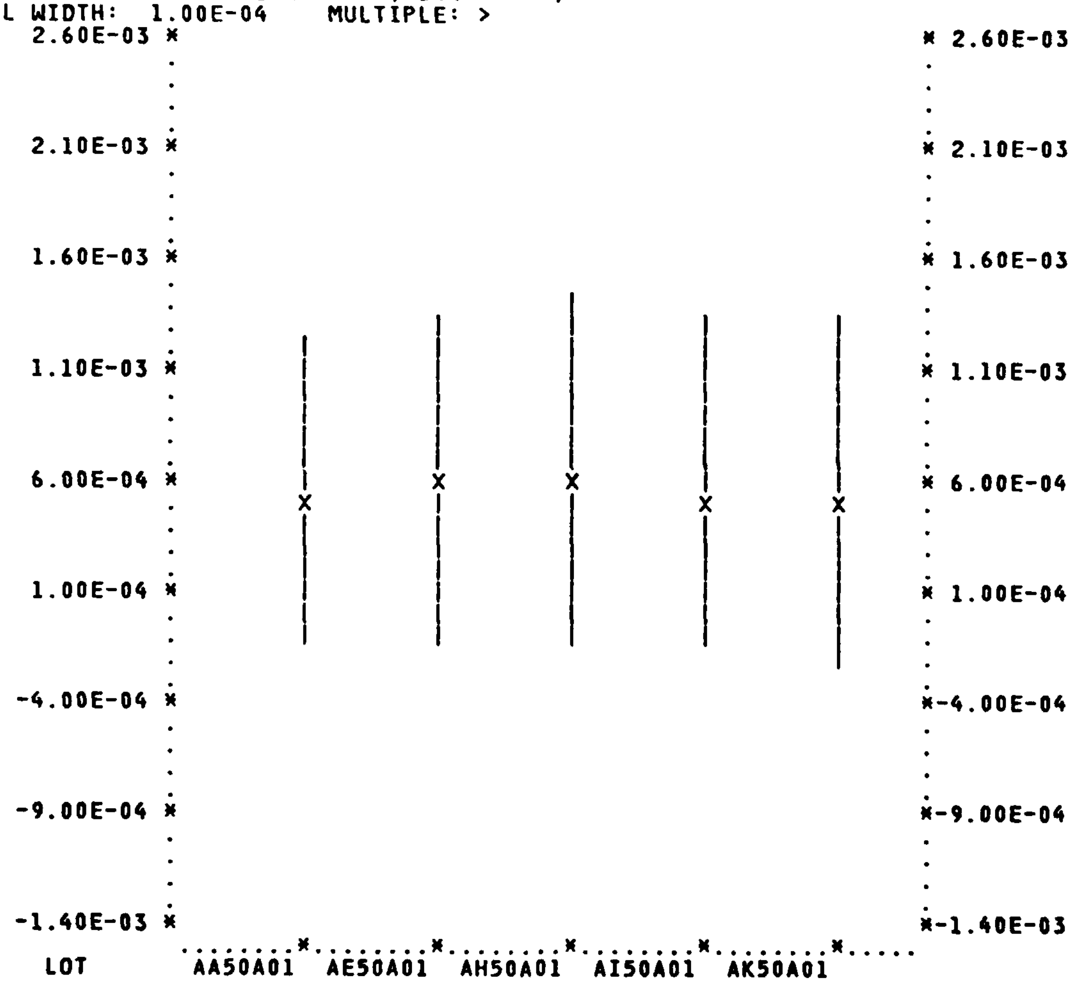

Fig. IV-13 - Trend analysis (continued).

```
DATE PRINTED : 07/18/81                          TIME PRINTED : 3.37.18
VIO(T1) VS TIME
TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND
LOT  =AA50A01 OR AE50A01 OR AH50A01 OR AI50A01 OR AK50A01
    Y=MED OR 17% OR 84%

TREND PLOT FOR: TYPE     = CA741
                TEST     =       6  PARAMETER: IIO
LEGEND: /MED      =X/17%     =|/84%     =|/
CELL WIDTH:  1.50E-09    MULTIPLE: >
```

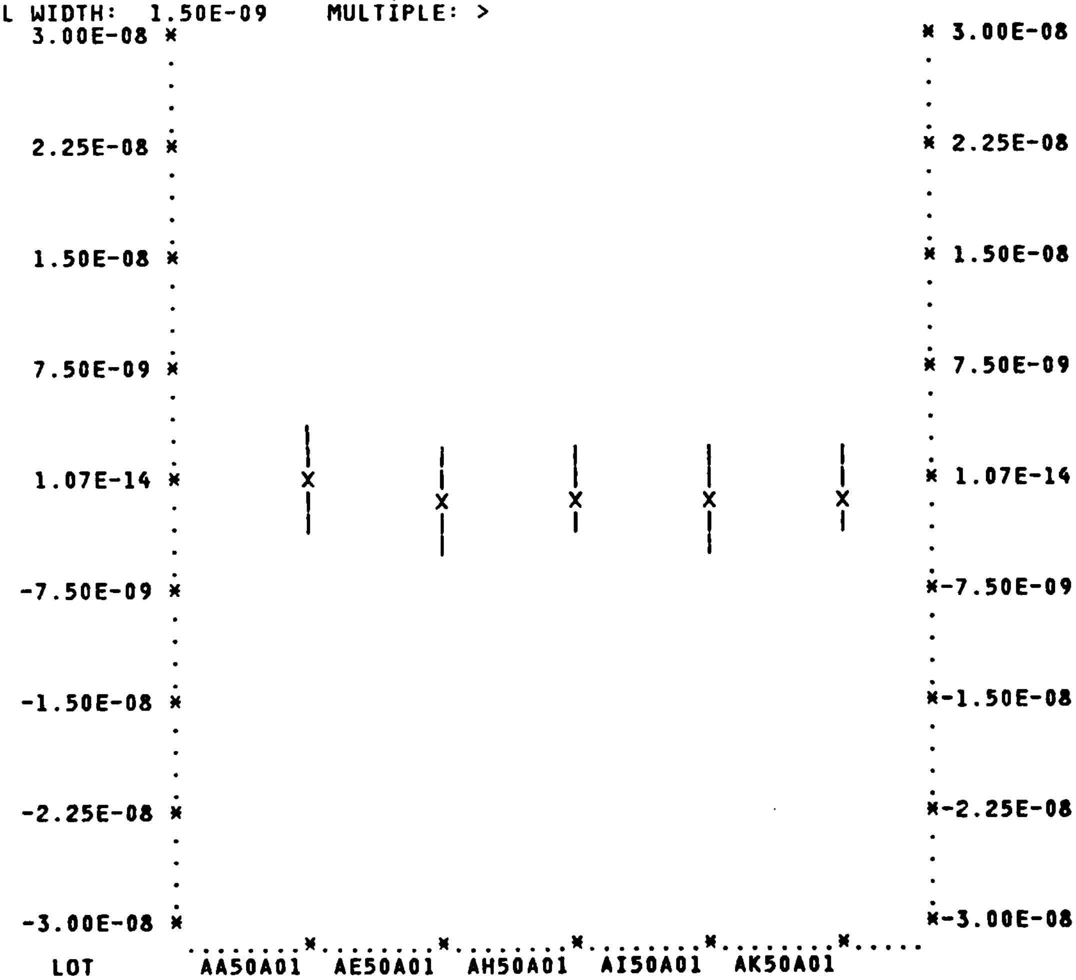

Fig. IV-13 - Trend analysis (continued).

DATE PRINTED : 07/18/81 TIME PRINTED : 3.37.18
VIO(T1) VS TIME
TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND
LOT =AA50A01 OR AE50A01 OR AH50A01 OR AI50A01 OR AK50A01
Y=MED OR 17% OR 84%

TREND PLOT FOR: TYPE = CA741
TEST = 8
LEGEND: /MED =X/17% =|/84% =|/
CELL WIDTH: 1.00E-09 MULTIPLE: >

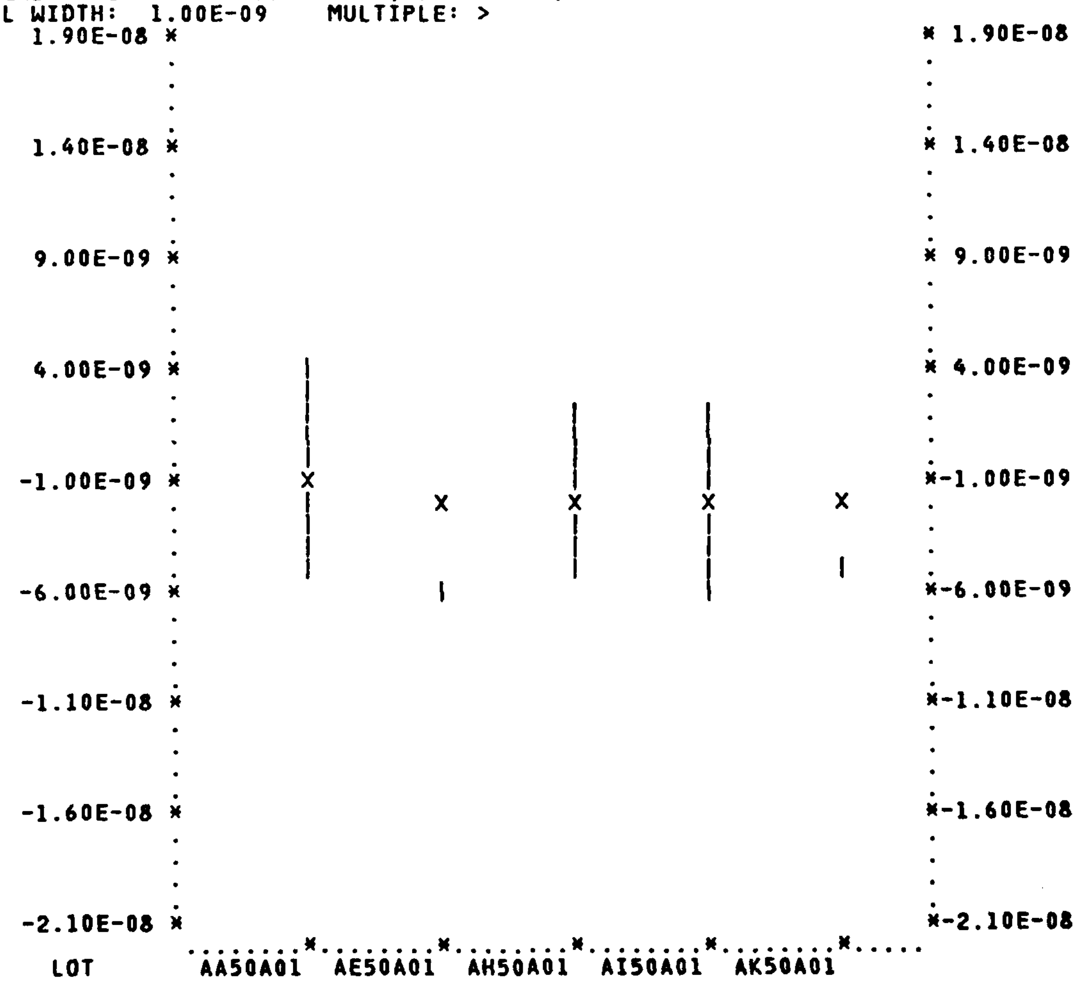

Fig. IV-13 - Trend analysis (continued).

DATE PRINTED : 07/18/81 TIME PRINTED : 3.37.18
VIO(T1) VS TIME
TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND
LOT =AA50A01 OR AE50A01 OR AH50A01 OR AI50A01 OR AK50A01
Y=MED OR 17% OR 84%

TREND PLOT FOR: TYPE = CA741
TEST = 10
LEGEND: /MED =X/17% =|/84% =|/
CELL WIDTH: 2.00E-10 MULTIPLE: >

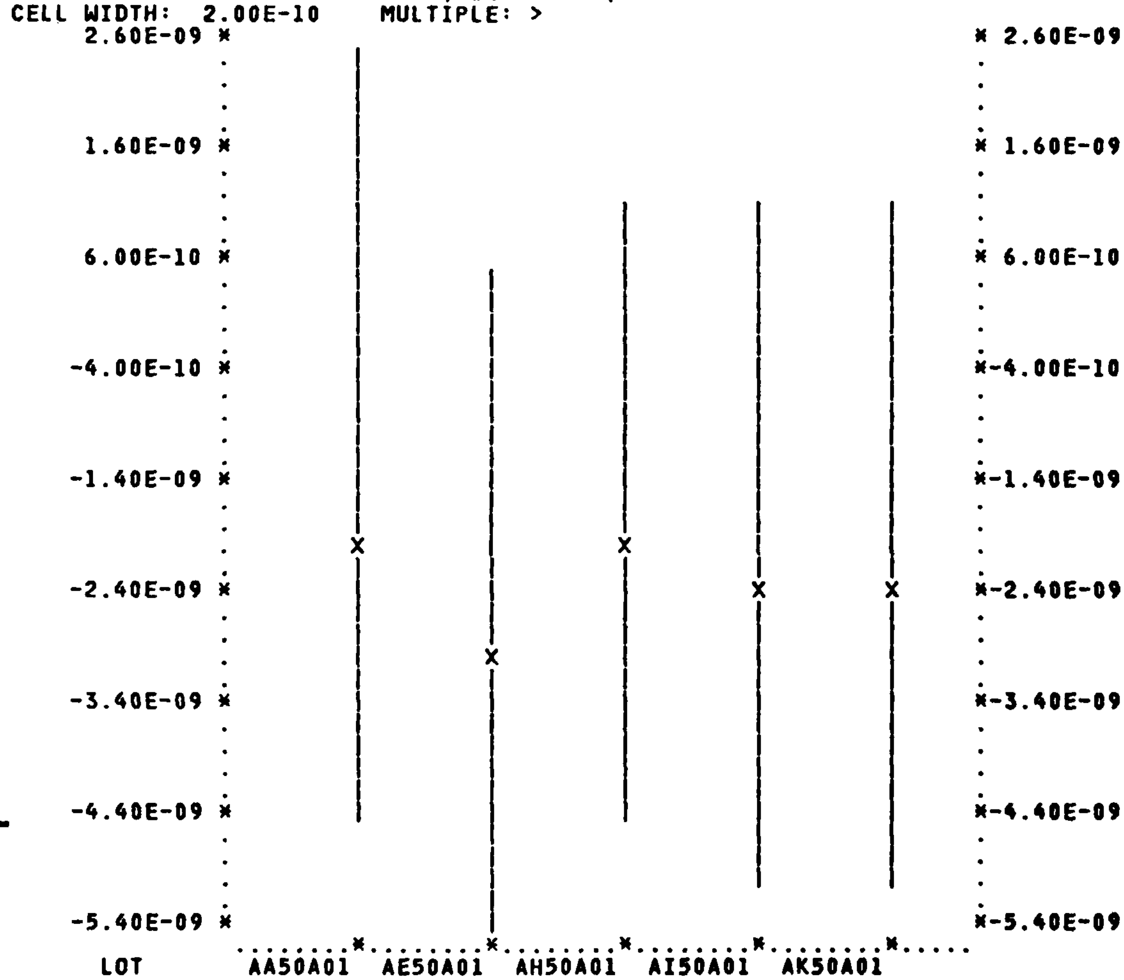

Fig. IV-13 - Trend analysis (continued).

DATE PRINTED : 07/18/81 TIME PRINTED : 3.37.18
VIO(T1) VS TIME
TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND
LOT =AA50A01 OR AE50A01 OR AH50A01 OR AI50A01 OR AK50A01
Y=MED OR 17% OR 84%

TREND PLOT FOR: TYPE = CA741
TEST = 12
LEGEND: /MED =X/17% =|/84% =|/
CELL WIDTH: 2.00E-10 MULTIPLE: >

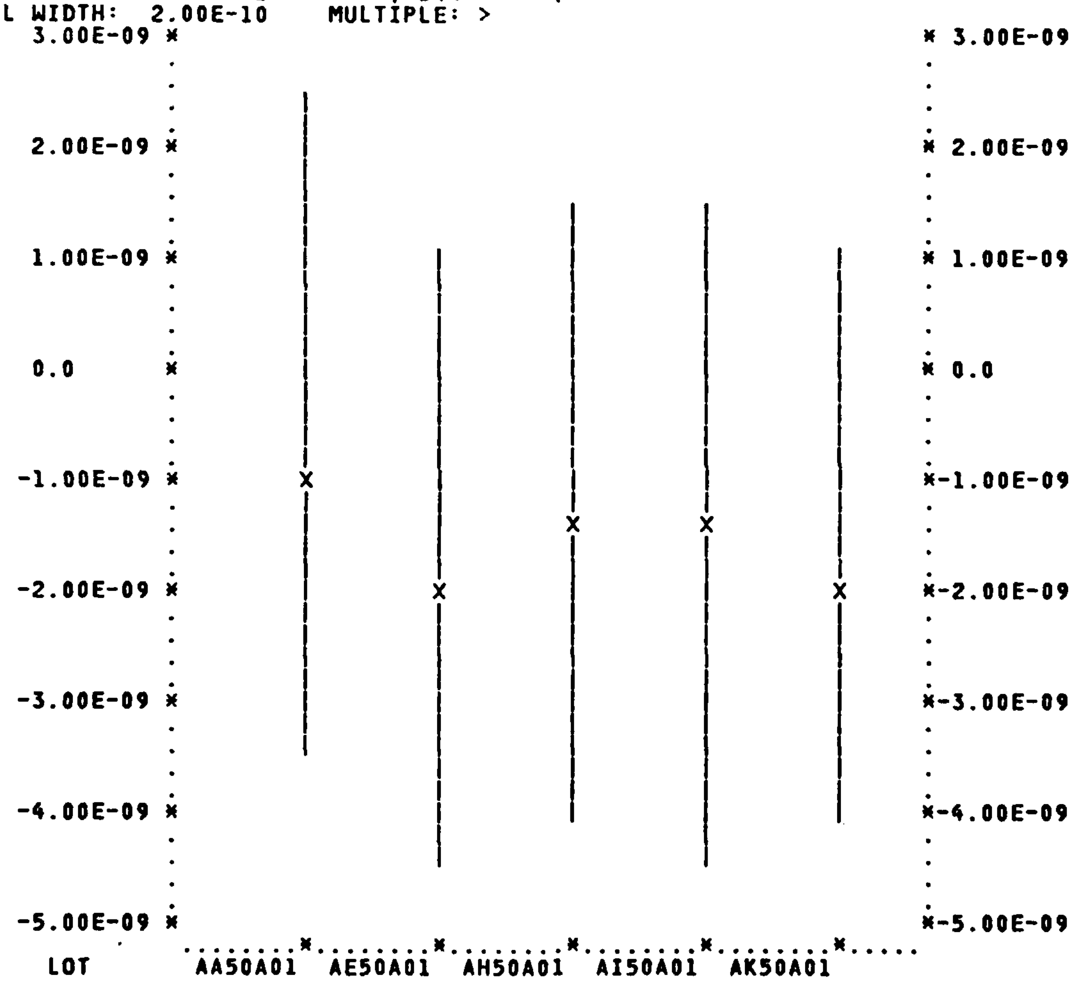

Fig. IV-13 - Trend analysis (continued).

```
DATE PRINTED : 07/18/81                        TIME PRINTED : 3.37.18
VIO(T1) VS TIME
TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND
LOT  =AA50A01 OR AE50A01 OR AH50A01 OR AI50A01 OR AK50A01
    Y=MED OR 17% OR 84%

TREND PLOT FOR: TYPE    = CA741
                TEST    =       14  PARAMETER: +IIB
LEGEND: /MED     =X/17%     =|/84%     =|/
CELL WIDTH:  4.95E-09    MULTIPLE: >
```

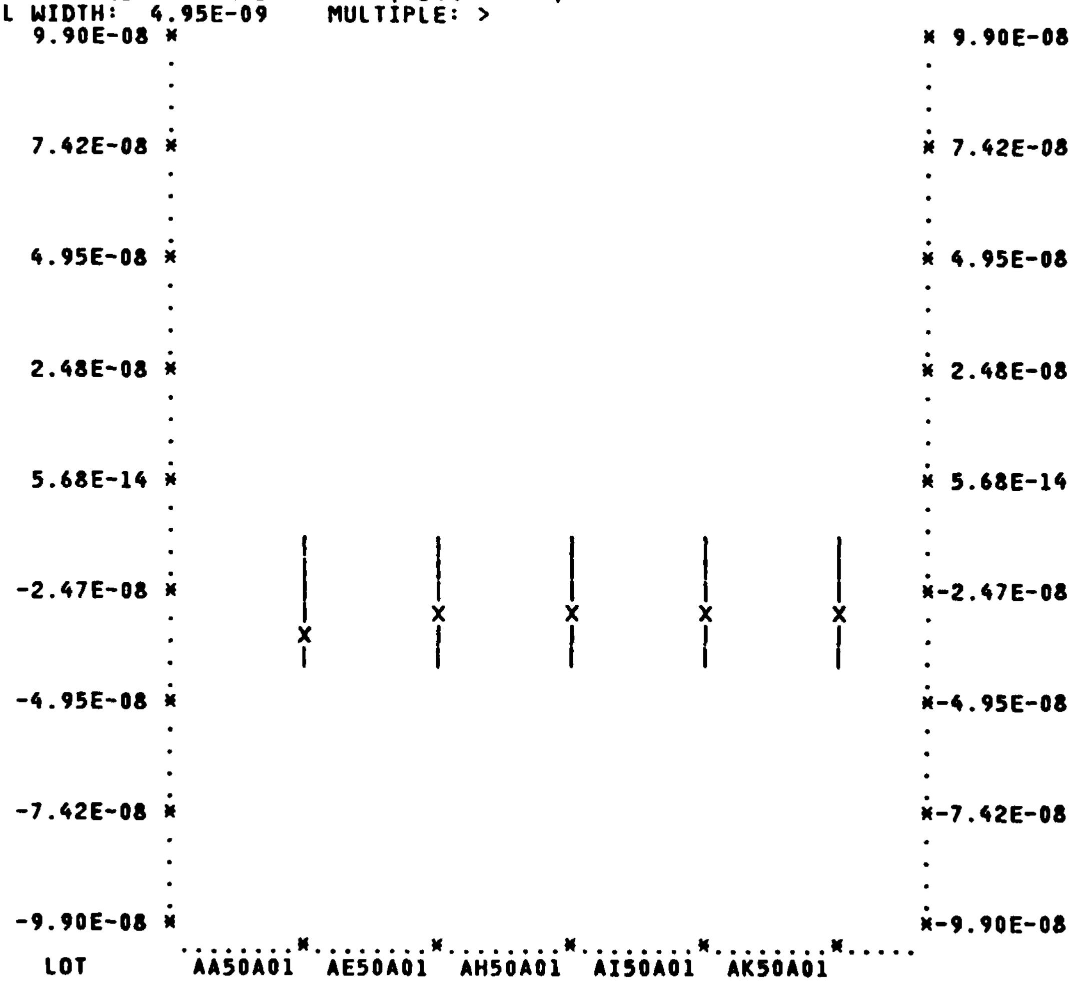

Fig. IV-13 - Trend analysis (continued).

```
DATE PRINTED : 07/18/81                              TIME PRINTED : 3.37.18
VIO(T1) VS TIME
TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND
LOT  =AA50A01 OR AE50A01 OR AH50A01 OR AI50A01 OR AK50A01
    Y=MED OR 17% OR 84%

TREND PLOT FOR: TYPE    = CA741
                TEST    =     16
LEGEND: /MED      =X/17%     =|/84%     =|/
CELL WIDTH:  1.00E-09    MULTIPLE: >
```

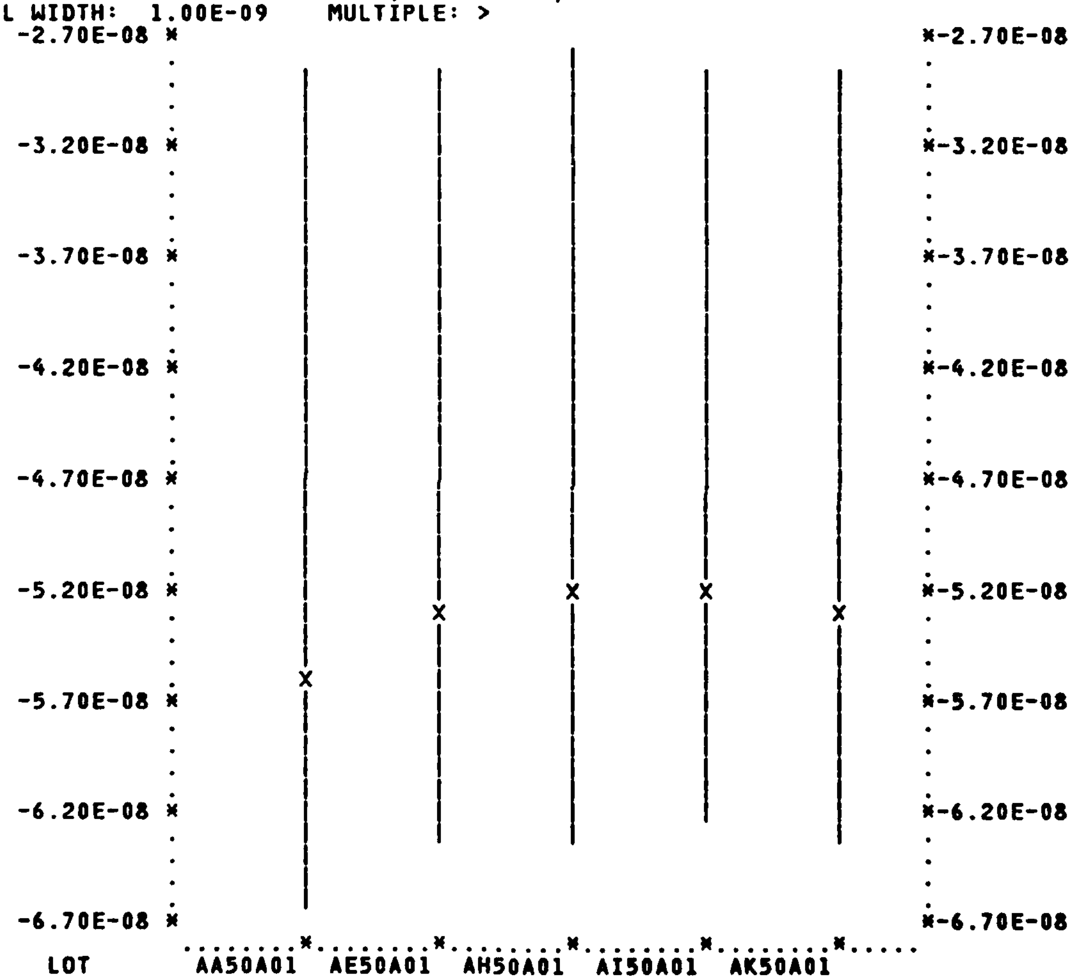

Fig. IV-13 - Trend analysis (continued).

DATE PRINTED : 07/18/81 TIME PRINTED : 3.37.18
VIO(T1) VS TIME
TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND
LOT =AA50A01 OR AE50A01 OR AH50A01 OR AI50A01 OR AK50A01
Y=MED OR 17% OR 84%

TREND PLOT FOR: TYPE = CA741
TEST = 18
LEGEND: /MED =X/17% =|/84% =|/
CELL WIDTH: 1.00E-09 MULTIPLE: >

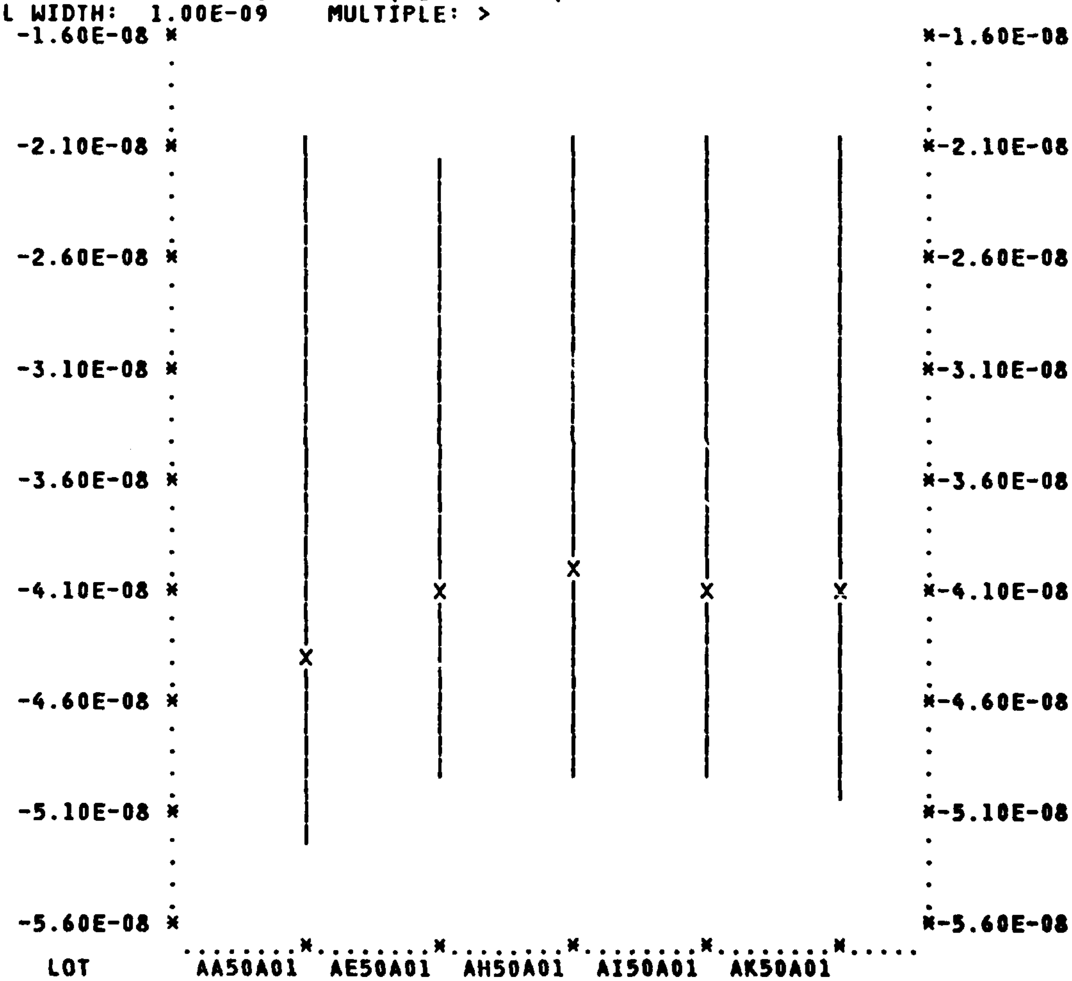

Fig. IV-13 - Trend analysis (continued).

DATE PRINTED : 07/18/81 TIME PRINTED : 3.37.18
VIO(T1) VS TIME
TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND
LOT =AA50A01 OR AE50A01 OR AH50A01 OR AI50A01 OR AK50A01
Y=MED OR 17% OR 84%

TREND PLOT FOR: TYPE = CA741
TEST = 20
LEGEND: /MED =X/17% =|/84% =|/
CELL WIDTH: 1.00E-09 MULTIPLE: >

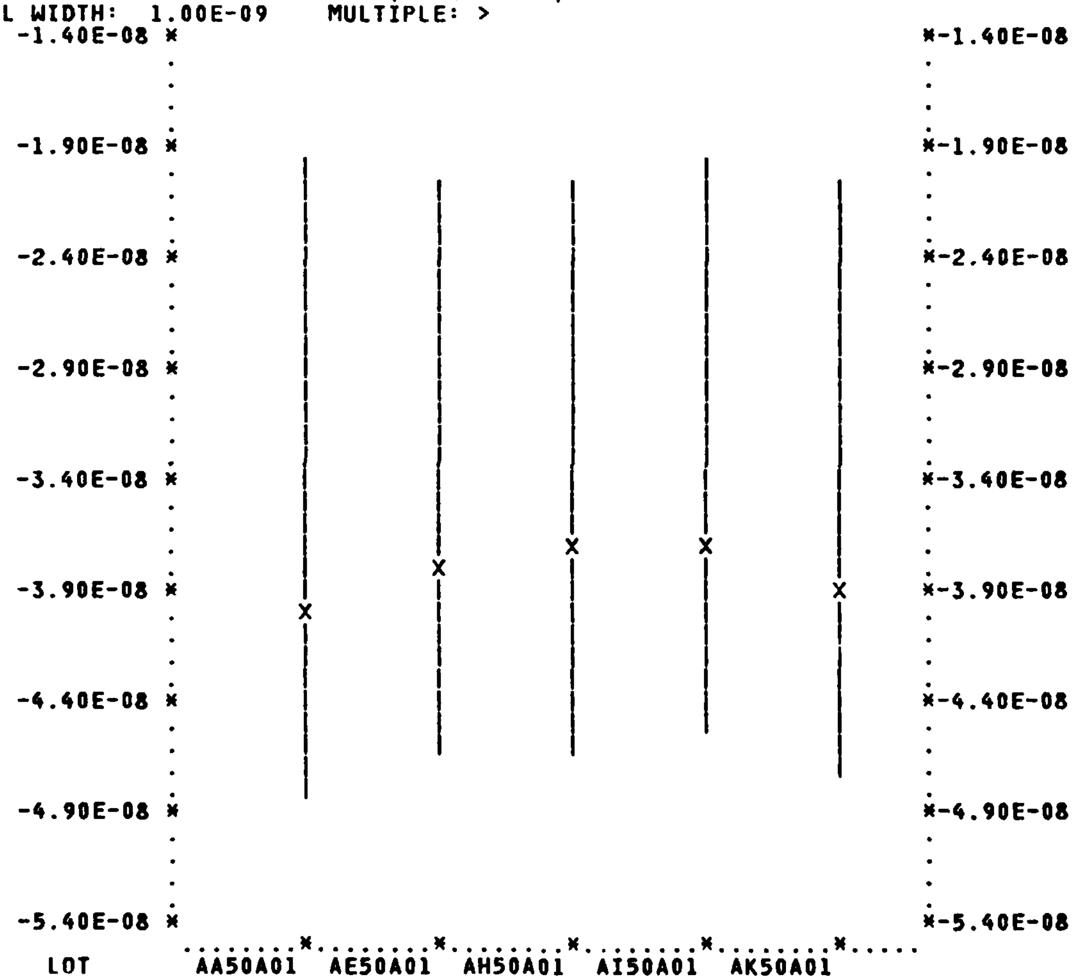

Fig. IV-13 - Trend analysis (continued).

DATE PRINTED : 07/18/81 TIME PRINTED : 3.37.18
VIO(T1) VS TIME
TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND
LOT =AA50A01 OR AE50A01 OR AH50A01 OR AI50A01 OR AK50A01
Y=MED OR 17% OR 84%

TREND PLOT FOR: TYPE = CA741
TEST = 22 PARAMETER: -IIB
LEGEND: /MED =X/17% =|/84% =|/
CELL WIDTH: 4.95E-09 MULTIPLE: >

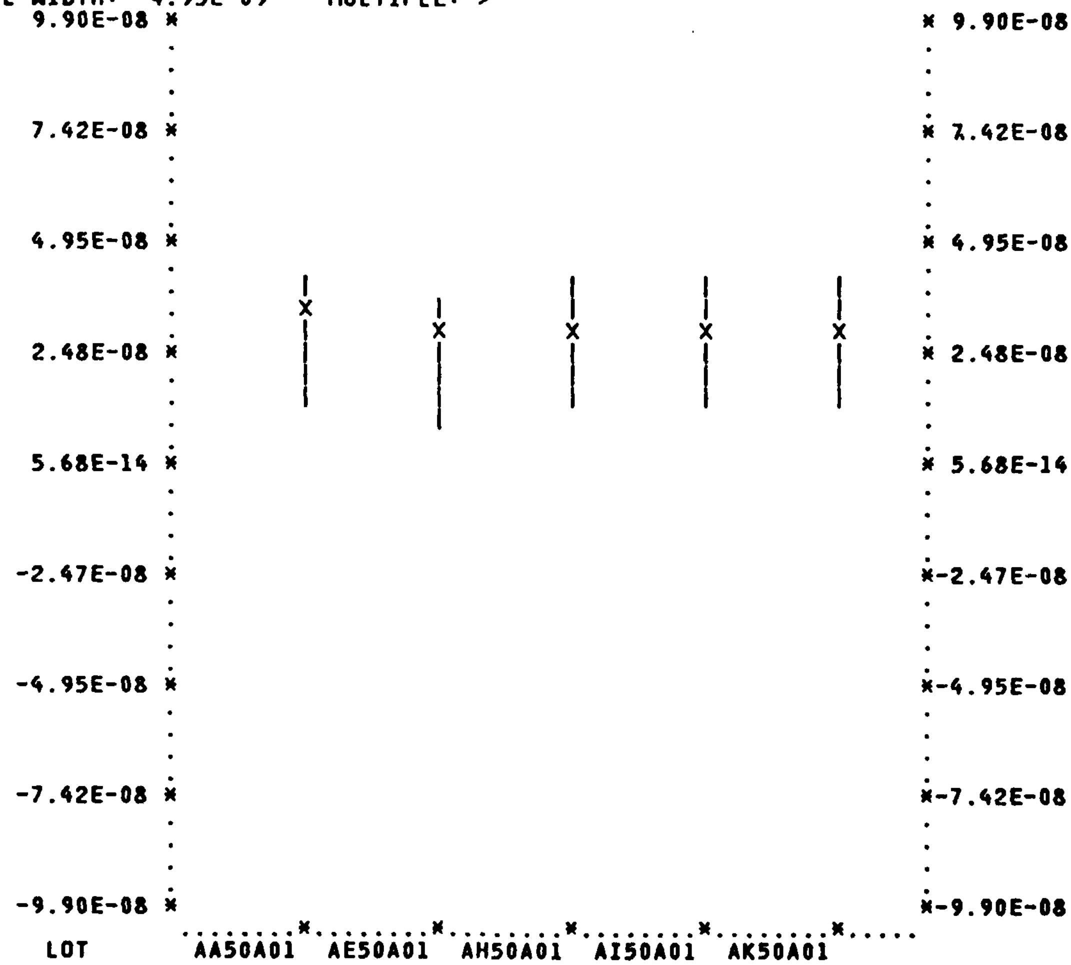

Fig. IV-13 - Trend analysis (continued).

DATE PRINTED : 07/18/81 TIME PRINTED : 3.37.18
VIO(T1) VS TIME
TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND
LOT =AA50A01 OR AE50A01 OR AH50A01 OR AI50A01 OR AK50A01
Y=MED OR 17% OR 84%

TREND PLOT FOR: TYPE = CA741
TEST = 24
LEGEND: /MED =X/17% =|/84% =|/
CELL WIDTH: 2.00E-09 MULTIPLE: >

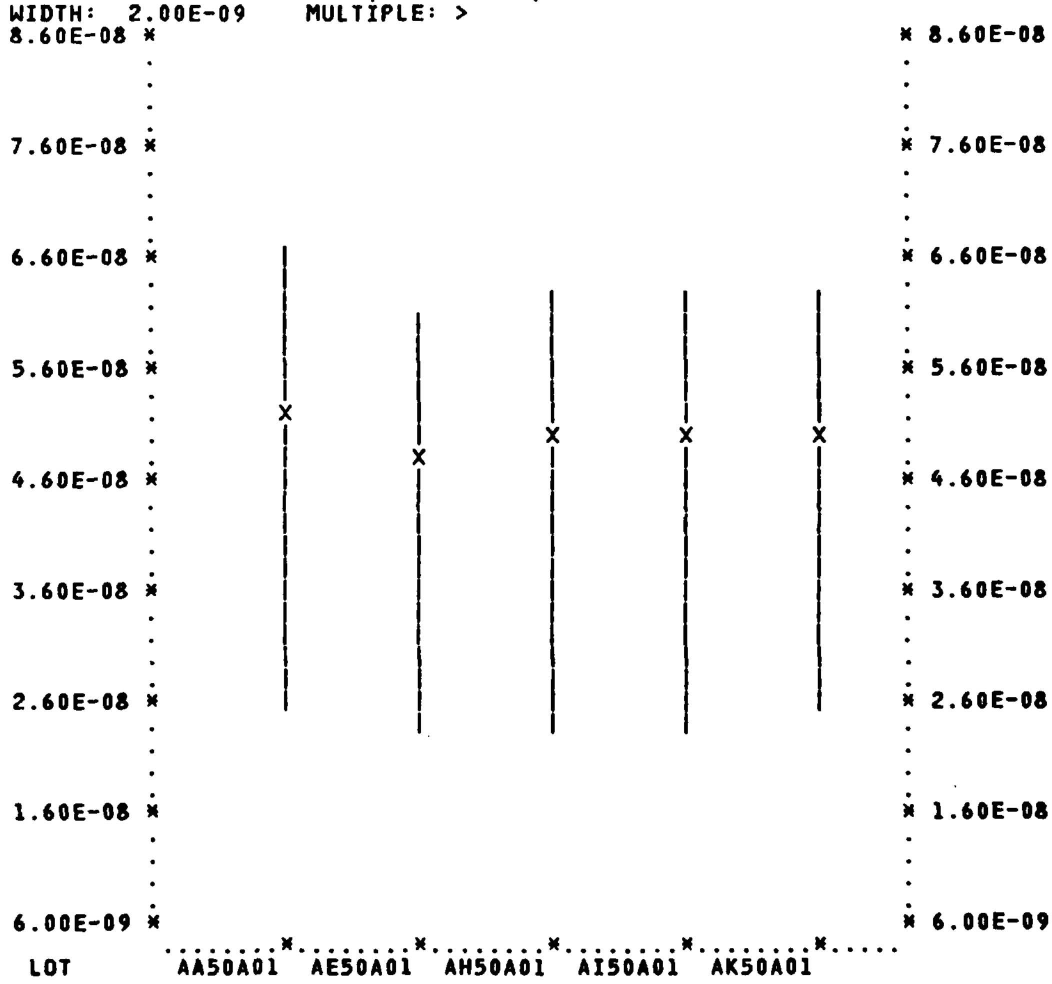

Fig. IV-13 - Trend analysis (continued).

DATE PRINTED : 07/18/81 TIME PRINTED : 3.37.18
VIO(T1) VS TIME
TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND
LOT =AA50A01 OR AE50A01 OR AH50A01 OR AI50A01 OR AK50A01
Y=MED OR 17% OR 84%

TREND PLOT FOR: TYPE = CA741
TEST = 26
LEGEND: /MED =X/17% =|/84% =|/
CELL WIDTH: 1.00E-09 MULTIPLE: >

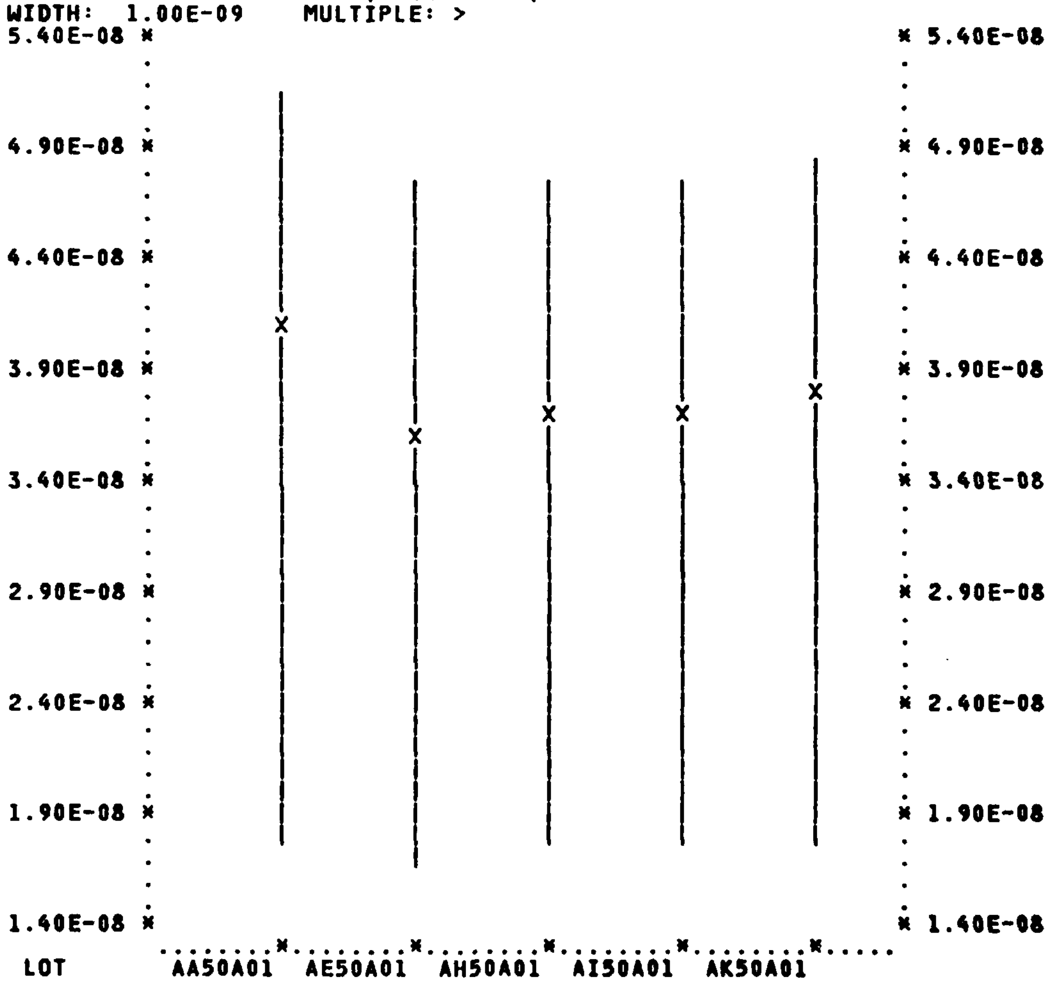

Fig. IV-13 - Trend analysis (continued).

DATE PRINTED : 07/18/81 TIME PRINTED : 3.37.18
VIO(T1) VS TIME .
TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND
LOT =AA50A01 OR AE50A01 OR AH50A01 OR AI50A01 OR AK50A01
Y=MED OR 17% OR 84%

TREND PLOT FOR: TYPE = CA741
TEST = 28
LEGEND: /MED =X/17% =|/84% =|/
CELL WIDTH: 1.00E-09 MULTIPLE: >

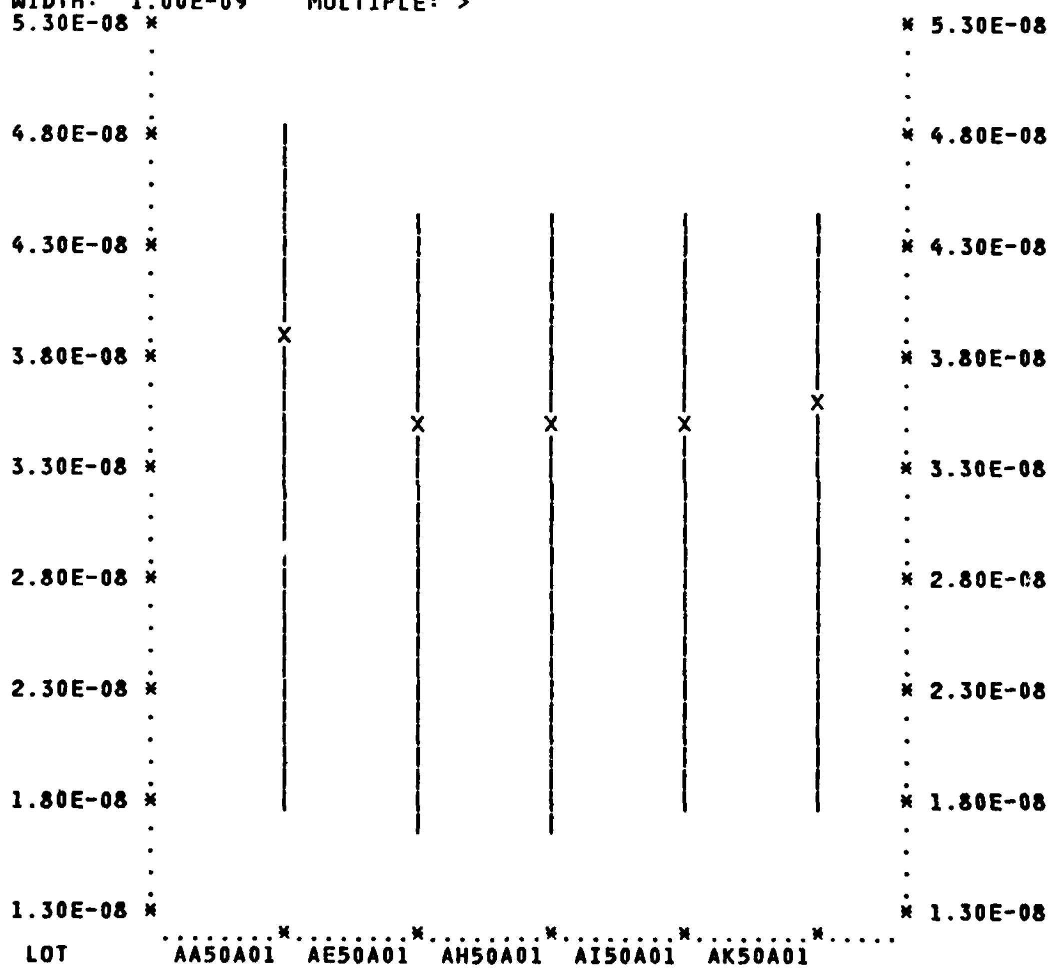

Fig. IV-13 - Trend analysis (continued).

```
DATE PRINTED : 07/18/81                              TIME PRINTED : 3.37.18
VIO(T1) VS TIME
TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND
LOT  =AA50A01 OR AE50A01 OR AH50A01 OR AI50A01 OR AK50A01
    Y=MED OR 17% OR 84%

TREND PLOT FOR: TYPE     = CA741
                TEST     =      30  PARAMETER: +PSRR
LEGEND: /MED      =X/17%      =|/84%      =|/
CELL WIDTH:  1.00E-08    MULTIPLE: >
     2.00E-07 *                                                   * 2.00E-07
              .                                                   .
              .                                                   .
              .                                                   .
              .                                                   .
     1.50E-07 *                                                   * 1.50E-07
              .                                                   .
              .                                                   .
              .                                                   .
              .                                                   .
     1.00E-07 *                                                   * 1.00E-07
              .                                                   .
              .                                                   .
              .                                                   .
              .                                                   .
     5.00E-08 *                                                   * 5.00E-08
              .                                                   .
              .                                                   .
              .                                                   .
              .                                                   .
     5.68E-14 *                                                   * 5.68E-14
              .                                                   .
              .                                                   .
              .                                                   .
              .                                                   .
    -5.00E-08 *                                                   *-5.00E-08
              .                                                   .
              .                                                   .
              .                                                   .
              .                                                   .
    -1.00E-07 *                                                   *-1.00E-07
              .                                                   .
              .                                                   .
              .                                                   .
              .                                                   .
    -1.50E-07 *                                                   *-1.50E-07
              .                                                   .
              .                                                   .
              .                                                   .
              .                                                   .
    -2.00E-07 *                                                   *-2.00E-07
               ........*........*........*........*........*.....
      LOT       AA50A01  AE50A01  AH50A01  AI50A01  AK50A01
```

Fig. IV-13 - Trend analysis (continued).

```
DATE PRINTED : 07/18/81                        TIME PRINTED : 3.37.18
VIO(T1) VS TIME
TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND
LOT  =AA50A01 OR AE50A01 OR AH50A01 OR AI50A01 OR AK50A01
    Y=MED OR 17% OR 84%

TREND PLOT FOR: TYPE     = CA741
                TEST     =      32  PARAMETER: -PSRR
LEGEND: /MED     =X/17%      =|/84%      =|/
CELL WIDTH:  1.00E-08    MULTIPLE: >
     2.00E-07 *                                                   * 2.00E-07
              .                                                   .
              .                                                   .
              .                                                   .
              .                                                   .
     1.50E-07 *                                                   * 1.50E-07
              .                                                   .
              .                                                   .
              .                                                   .
              .                                                   .
     1.00E-07 *                                                   * 1.00E-07
              .                                                   .
              .                                                   .
              .                                                   .
              .                                                   .
     5.00E-08 *                                                   * 5.00E-08
              .                                                   .
              .                                                   .
              .                                                   .
              .                                                   .
     5.68E-14 *                                                   * 5.68E-14
              .                                                   .
              .                                                   .
              .                                                   .
              .                                                   .
    -5.00E-08 *                                                   *-5.00E-08
              .                                                   .
              .                                                   .
              .                                                   .
              .                                                   .
    -1.00E-07 *                                                   *-1.00E-07
              .                                                   .
              .                                                   .
              .                                                   .
              .                                                   .
    -1.50E-07 *                                                   *-1.50E-07
              .                                                   .
              .                                                   .
              .                                                   .
              .                                                   .
    -2.00E-07 *                                                   *-2.00E-07
               ........*........*........*........*........*.....
      LOT        AA50A01  AE50A01  AH50A01  AI50A01  AK50A01
```

Fig. IV-13 - Trend analysis (continued).

```
DATE PRINTED : 07/18/81                          TIME PRINTED : 3.37.18
VIO(T1) VS TIME
TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND
LOT  =AA50A01 OR AE50A01 OR AH50A01 OR AI50A01 OR AK50A01
    Y=MED OR 17% OR 84%

TREND PLOT FOR: TYPE     = CA741
                TEST     =      33  PARAMETER: CMRR
LEGEND: /MED     =X/17%     =|/84%     =|/
CELL WIDTH:  2.00E-02    MULTIPLE: >
```

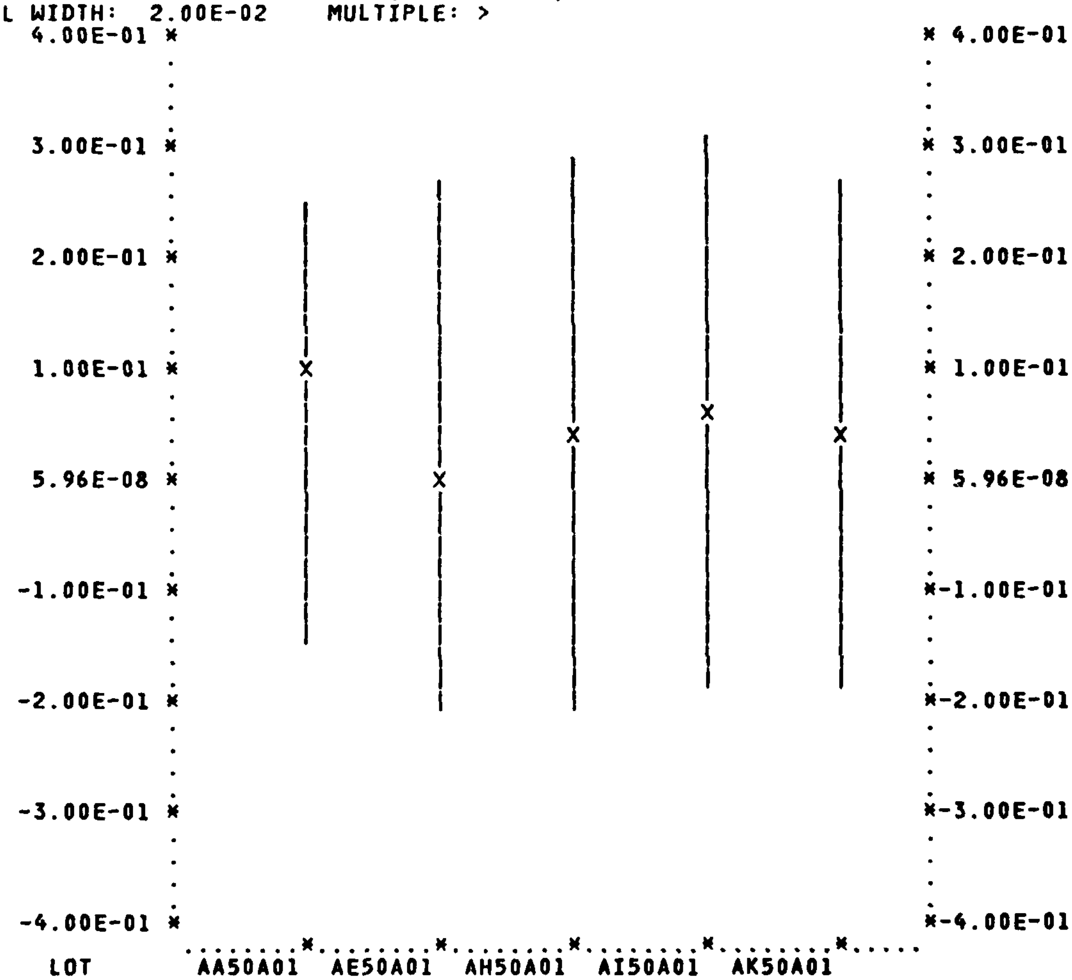

Fig. IV-13 - Trend analysis (continued).

DATE PRINTED : 07/18/81 TIME PRINTED : 3.37.18
VIO(T1) VS TIME
TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND
LOT =AA50A01 OR AE50A01 OR AH50A01 OR AI50A01 OR AK50A01
Y=MED OR 17% OR 84%

TREND PLOT FOR: TYPE = CA741
TEST = 34 PARAMETER: VIO(ADJ)+
LEGEND: /MED =X/17% =|/84% =|/
CELL WIDTH: 5.00E-01 MULTIPLE: >

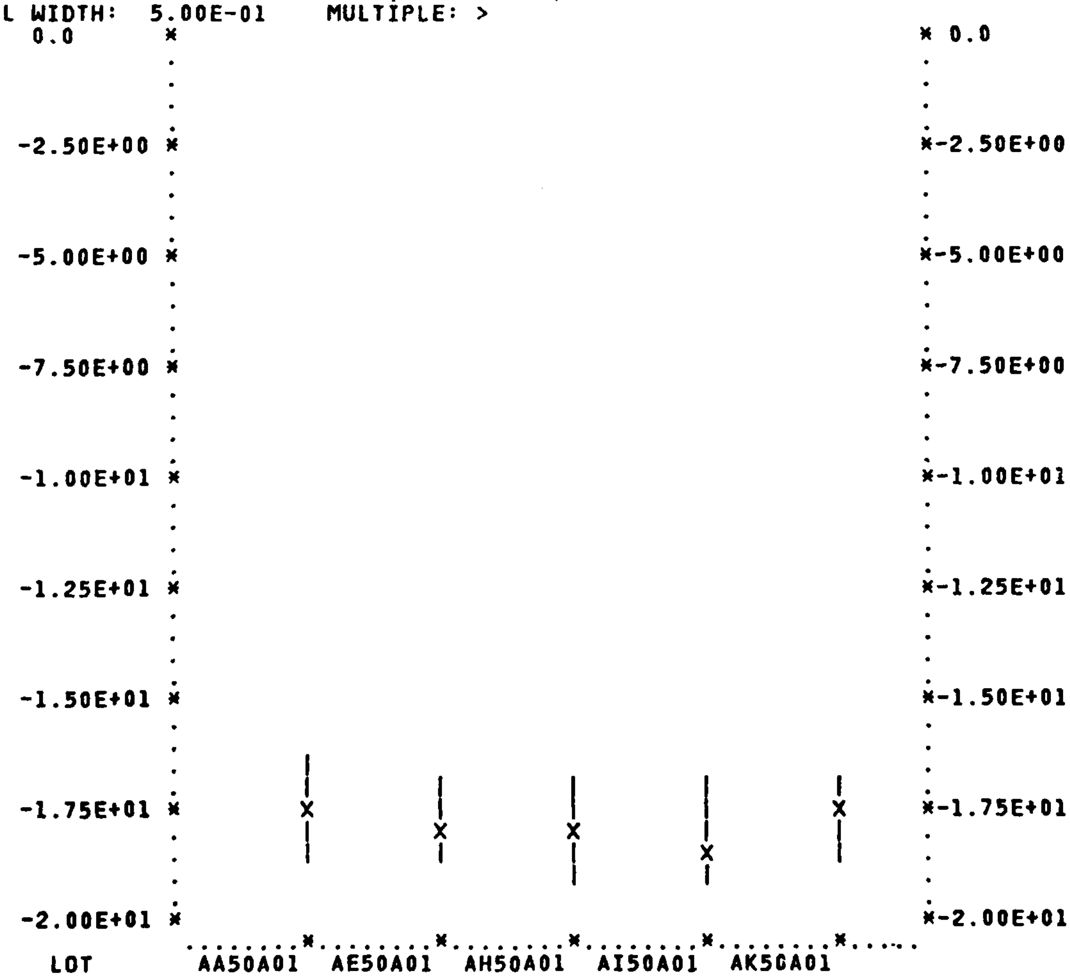

Fig. IV-13 - Trend analysis (continued).

```
DATE PRINTED : 07/18/81                           TIME PRINTED : 3.37.18
VIO(T1) VS TIME
TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND
LOT  =AA50A01 OR AE50A01 OR AH50A01 OR AI50A01 OR AK50A01
    Y=MED OR 17% OR 84%

TREND PLOT FOR: TYPE     = CA741
                TEST     =      35  PARAMETER: VIO(ADJ)-
LEGEND: /MED      =X/17%     =|/84%      =|/
CELL WIDTH:  5.00E-01    MULTIPLE: >
```

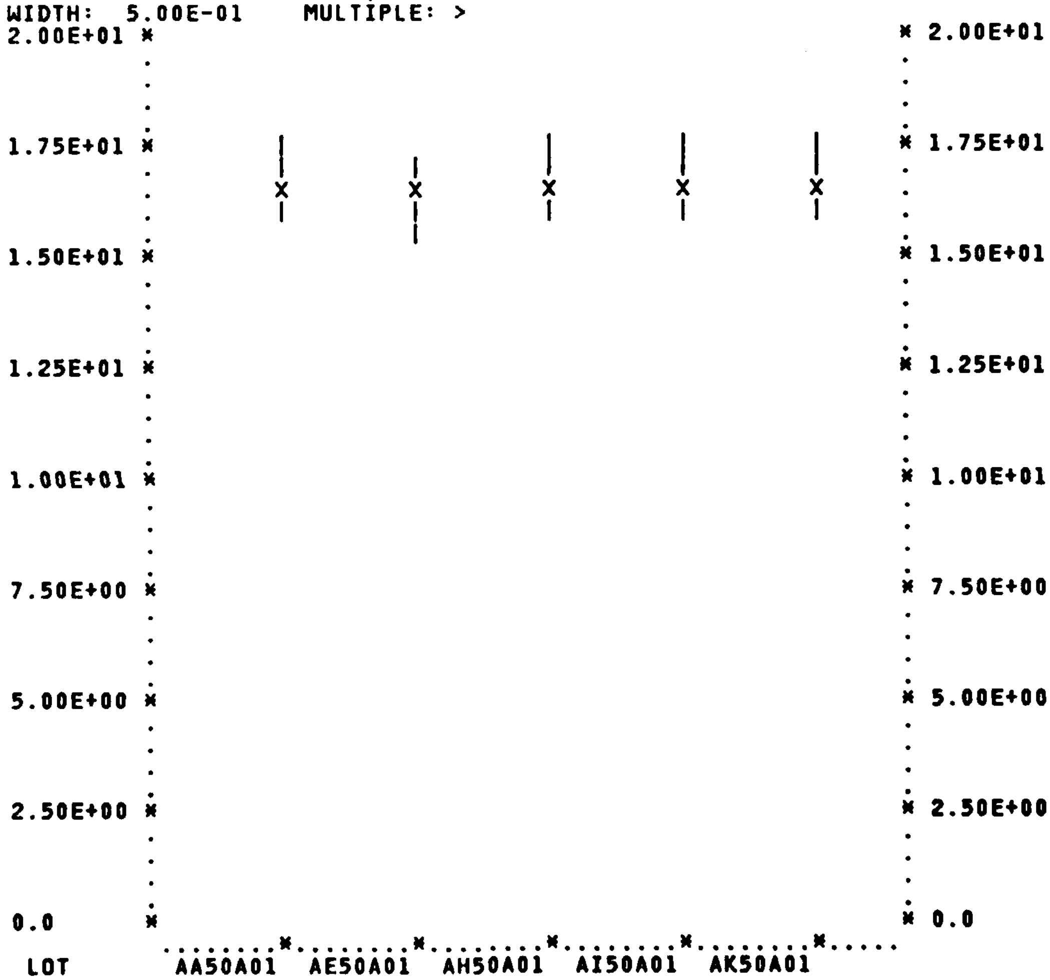

Fig. IV-13 - Trend analysis (continued).

```
DATE PRINTED : 07/18/81                          TIME PRINTED : 3.37.18
VIO(T1) VS TIME
TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND
LOT  =AA50A01 OR AE50A01 OR AH50A01 OR AI50A01 OR AK50A01
    Y=MED OR 17% OR 84%

TREND PLOT FOR: TYPE    = CA741
                TEST    =       36  PARAMETER: ICC
LEGEND: /MED      =X/17%     =|/84%     =|/
CELL WIDTH:  9.50E-05    MULTIPLE: >
     3.80E-03 *                                                     * 3.80E-03
              .                                                     .
              .                                                     .
              .                                                     .
     3.32E-03 *                                                     * 3.32E-03
              .                                                     .
              .                                                     .
              .                                                     .
     2.85E-03 *                                                     * 2.85E-03
              .                                                     .
              .                                                     .
              .                                                     .
     2.37E-03 *                                                     * 2.37E-03
              .                                                     .
              .                                                     .
              .                                                     .
     1.90E-03 *                                                     * 1.90E-03
              .                                                     .
              .                                                     .
              .                                                     .
     1.43E-03 *                                                     * 1.43E-03
              .                                                     .
              .                                                     .
              .                                                     .
     9.50E-04 *                                                     * 9.50E-04
              .                                                     .
              .                                                     .
              .                                                     .
     4.75E-04 *                                                     * 4.75E-04
              .                                                     .
              .                                                     .
              .                                                     .
     0.0      *                                                     * 0.0
               .........*.........*.........*.........*.........*.....
      LOT       AA50A01   AE50A01   AH50A01   AI50A01   AK50A01
```

Fig. IV-13 - Trend analysis (continued).

```
DATE PRINTED : 07/18/81                              TIME PRINTED : 3.37.18
VIO(T1) VS TIME
TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND
LOT  =AA50A01 OR AE50A01 OR AH50A01 OR AI50A01 OR AK50A01
    Y=MED OR 17% OR 84%

TREND PLOT FOR: TYPE    = CA741
                TEST    =      37  PARAMETER: IOS+
LEGEND: /MED     =X/17%     =|/84%     =|/
CELL WIDTH:  1.50E-04    MULTIPLE: >
     0.0     *                                                    * 0.0
             .                                                    .
             .                                                    .
             .                                                    .
 -7.50E-04   *                                                    *-7.50E-04
             .                                                    .
             .                                                    .
             .                                                    .
 -1.50E-03   *                                                    *-1.50E-03
             .                                                    .
             .                                                    .
             .                                                    .
 -2.25E-03   *                                                    *-2.25E-03
             .                                                    .
             .                                                    .
             .                                                    .
 -3.00E-03   *                                                    *-3.00E-03
             .                                                    .
             .                                                    .
             .                                                    .
 -3.75E-03   *                                                    *-3.75E-03
             .                                                    .
             .                                                    .
             .                                                    .
 -4.50E-03   *                                                    *-4.50E-03
             .                                                    .
             .                                                    .
             .                                                    .
 -5.25E-03   *                                                    *-5.25E-03
             .                                                    .
             .                                                    .
             .                                                    .
 -6.00E-03   *                                                    *-6.00E-03
              .........*.........*.........*.........*.........*.....
     LOT       AA50A01   AE50A01   AH50A01   AI50A01   AK50A01
```

Fig. IV-13 - Trend analysis (continued).

DATE PRINTED : 07/18/81 TIME PRINTED : 3.37.18
VIO(T1) VS TIME
TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND
LOT =AA50A01 OR AE50A01 OR AH50A01 OR AI50A01 OR AK50A01
Y=MED OR 17% OR 84%

TREND PLOT FOR: TYPE = CA741
TEST = 38 PARAMETER: IOS-
LEGEND: /MED =X/17% =|/84% =|/
CELL WIDTH: 1.50E-03 MULTIPLE: >

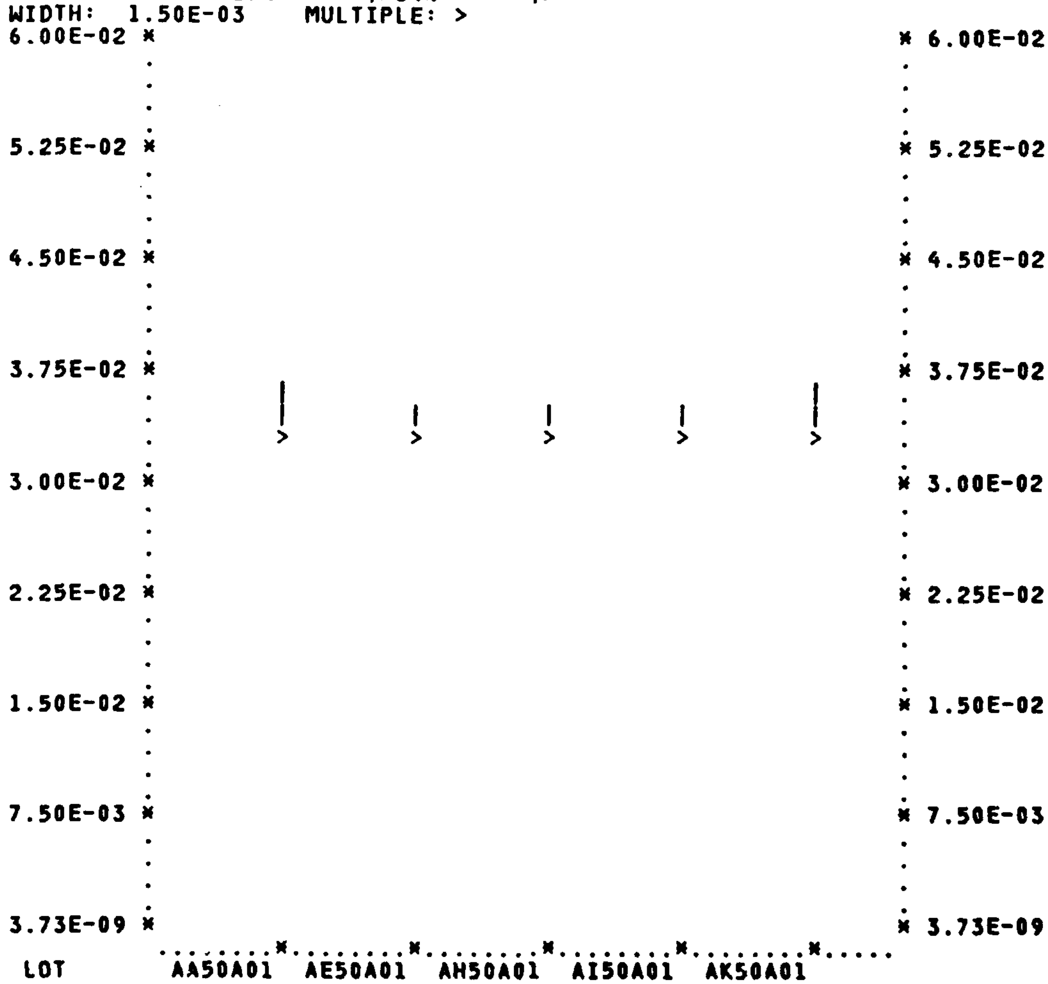

Fig. IV-13 - Trend analysis (continued).

```
DATE PRINTED : 07/18/81                    TIME PRINTED : 3.37.18
VIO(T1) VS TIME
TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND
LOT  =AA50A01 OR AE50A01 OR AH50A01 OR AI50A01 OR AK50A01
    Y=MED OR 17% OR 84%

TREND PLOT FOR: TYPE     = CA741
                TEST     =      39
LEGEND: /MED      =X/17%      =|/84%      =|/
CELL WIDTH:  1.00E-03    MULTIPLE: >
```

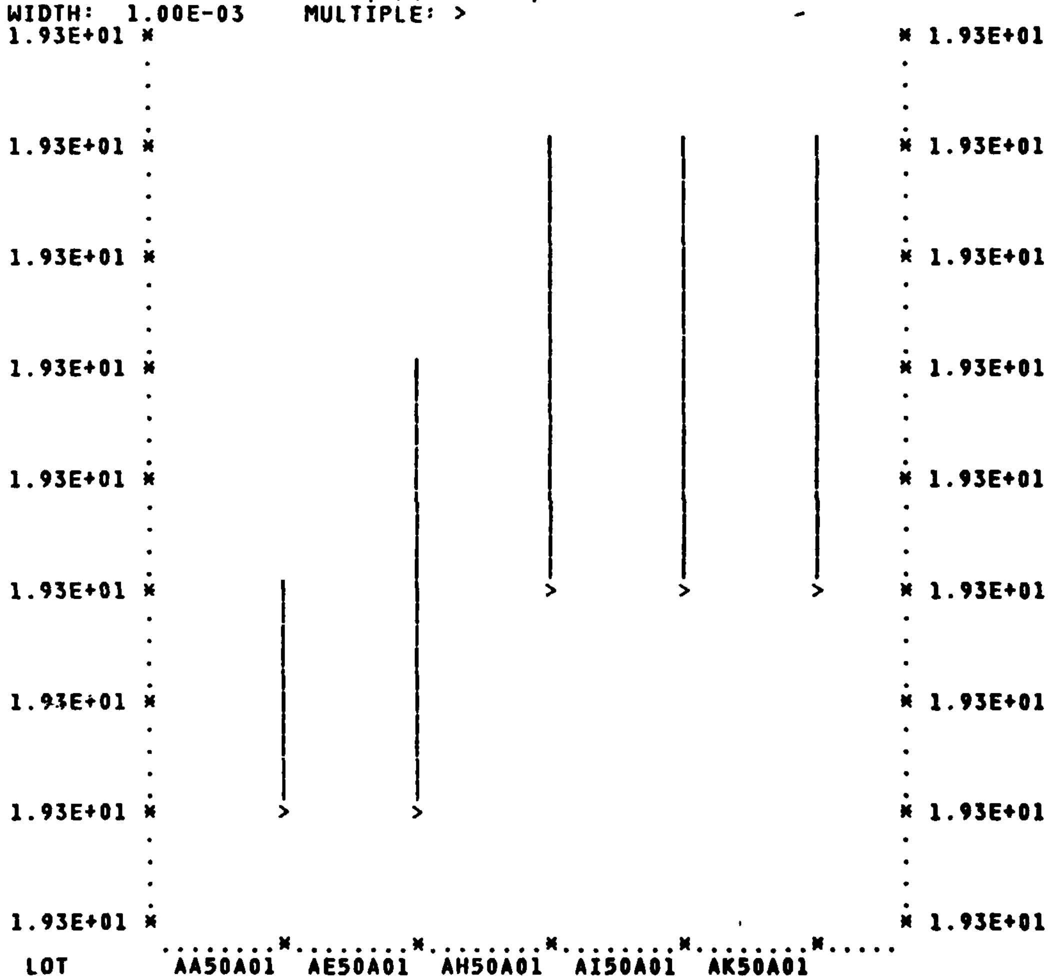

Fig. IV-13 - Trend analysis (continued).

DATE PRINTED : 07/18/81 TIME PRINTED : 3.37.18
VIO(T1) VS TIME
TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND
LOT =AA50A01 OR AE50A01 OR AH50A01 OR AI50A01 OR AK50A01
Y=MED OR 17% OR 84%

TREND PLOT FOR: TYPE = CA741
TEST = 40
LEGEND: /MED =X/17% =|/84% =|/
CELL WIDTH: 4.00E-03 MULTIPLE: >

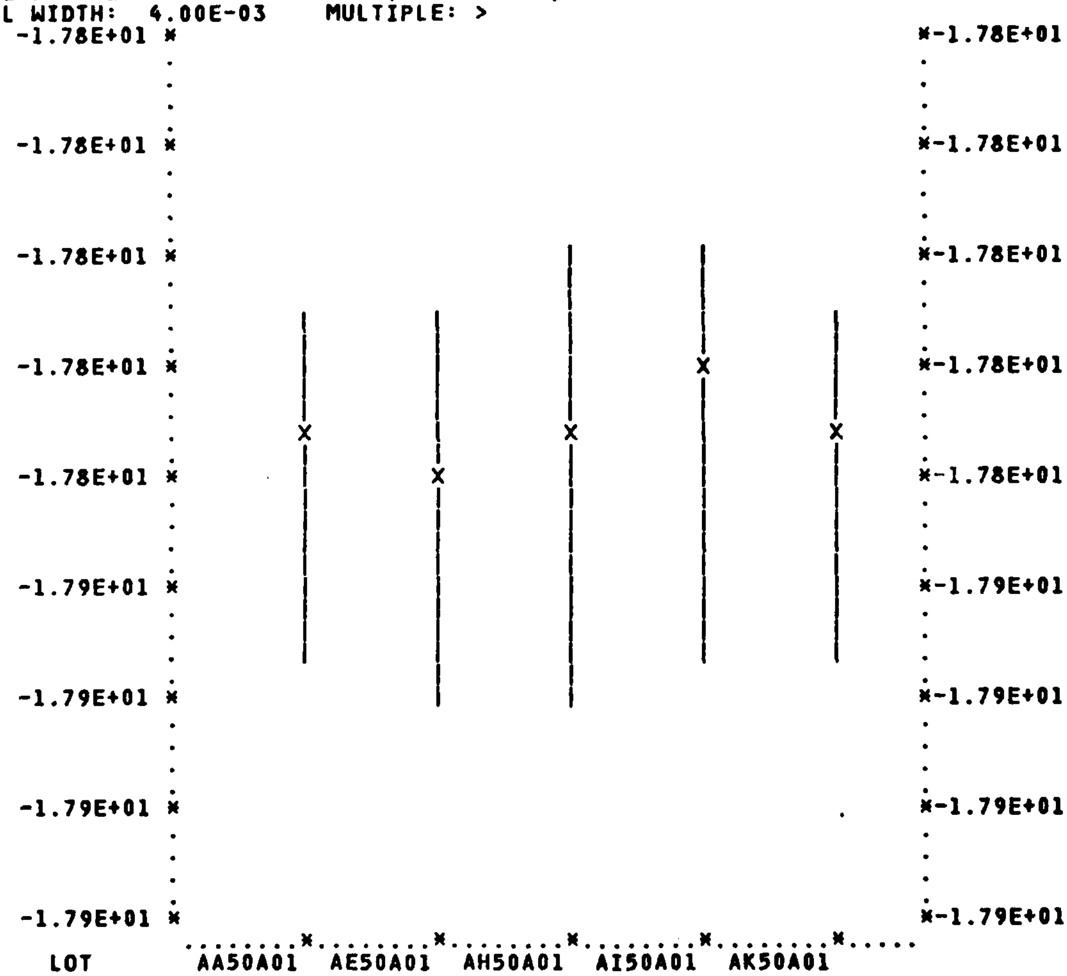

Fig. IV-13 - Trend analysis (continued).

```
DATE PRINTED : 07/18/81                              TIME PRINTED : 3.37.18
VIO(T1) VS TIME
TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND
LOT  =AA50A01 OR AE50A01 OR AH50A01 OR AI50A01 OR AK50A01
    Y=MED OR 17% OR 84%

TREND PLOT FOR: TYPE    = CA741
                TEST    =      42
LEGEND: /MED     =X/17%     =|/84%     =|/
CELL WIDTH:  2.00E-03    MULTIPLE: >
```

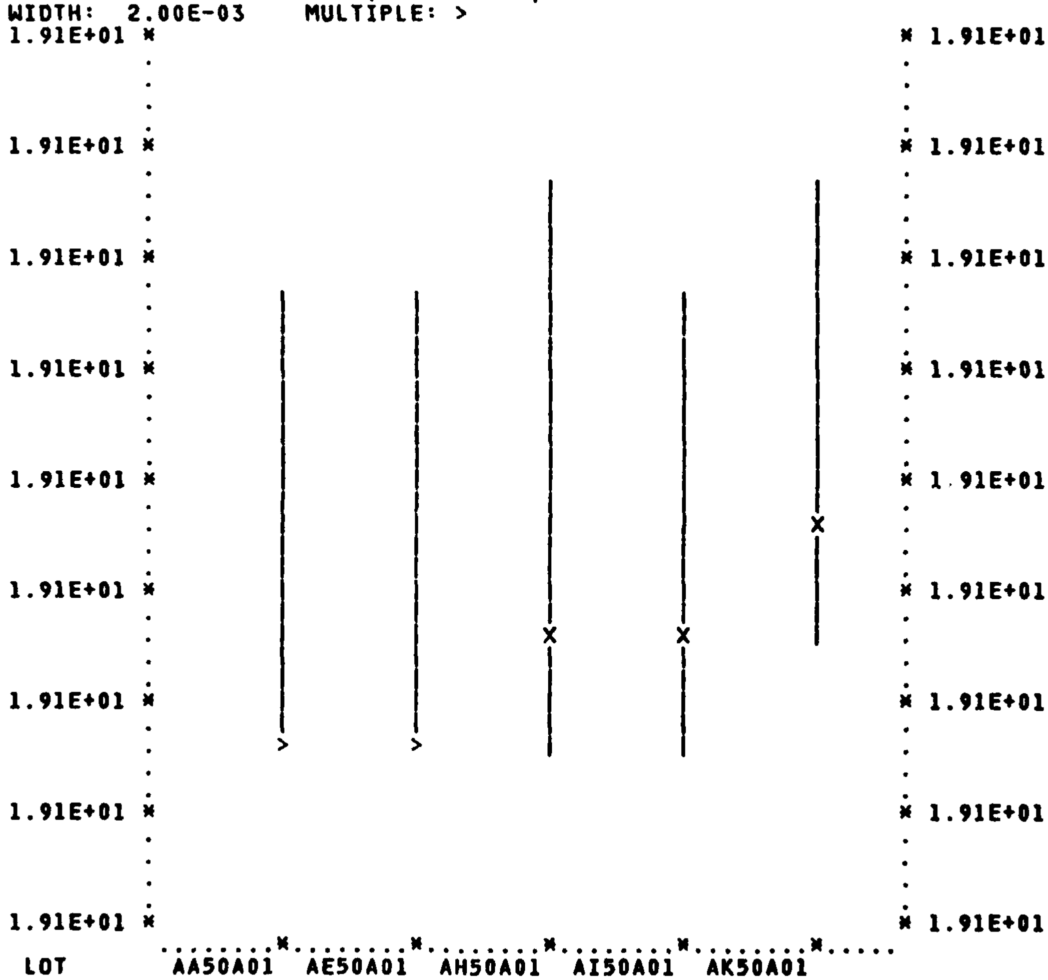

Fig. IV-13 - Trend analysis (continued).

DATE PRINTED : 07/18/81 TIME PRINTED : 3.37.18
VIO(T1) VS TIME
TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND
LOT =AA50A01 OR AE50A01 OR AH50A01 OR AI50A01 OR AK50A01
Y=MED OR 17% OR 84%

TREND PLOT FOR: TYPE = CA741
TEST = 43
LEGEND: /MED =X/17% =|/84% =|/
CELL WIDTH: 1.00E-02 MULTIPLE: >

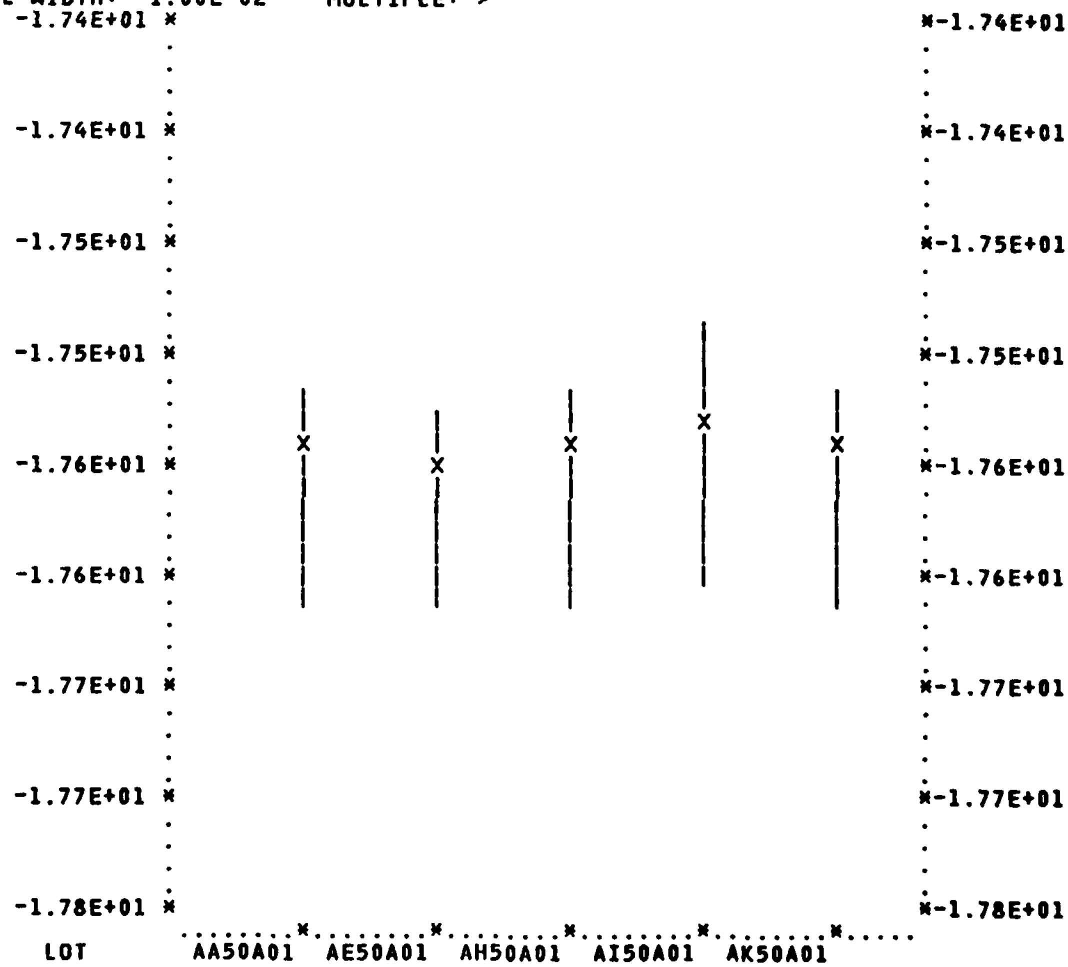

Fig. IV-13 - Trend analysis (continued).

DATE PRINTED : 07/18/81 TIME PRINTED : 3.37.18
VIO(T1) VS TIME
TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND
LOT =AA50A01 OR AE50A01 OR AH50A01 OR AI50A01 OR AK50A01
Y=MED OR 17% OR 84%

TREND PLOT FOR: TYPE = CA741
TEST = 45
LEGEND: /MED =X/17% =|/84% =|/
CELL WIDTH: 2.00E-03 MULTIPLE: >

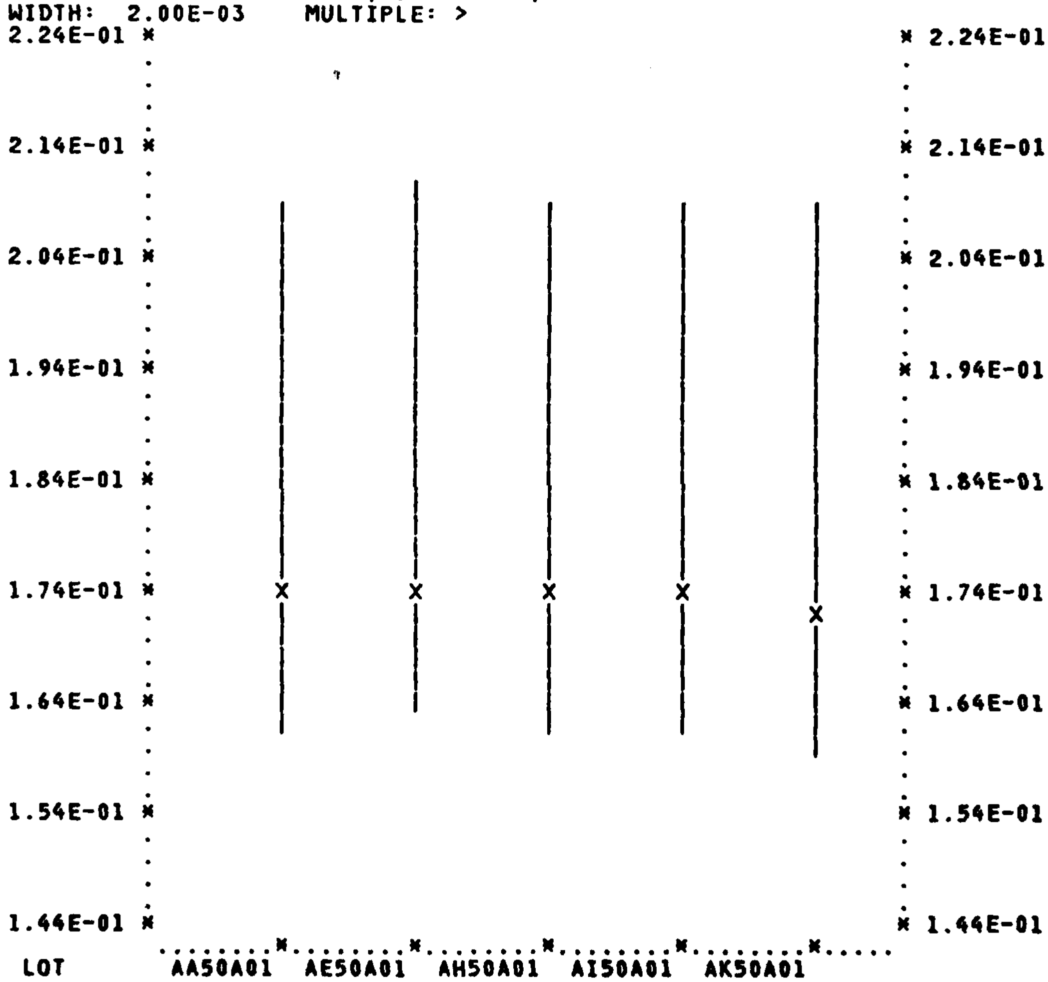

Fig. IV-13 - Trend analysis (continued).

```
DATE PRINTED : 07/18/81                        TIME PRINTED : 3.37.18
VIO(T1) VS TIME
TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND
LOT  =AA50A01 OR AE50A01 OR AH50A01 OR AI50A01 OR AK50A01
    Y=MED OR 17% OR 84%

TRENDPLOT FOR: TYPE    = CA741
               TEST    =     46
LEGEND: /MED      =X/17%     =|/84%     =|/
CELL WIDTH:  1.00E-03    MULTIPLE: >
```

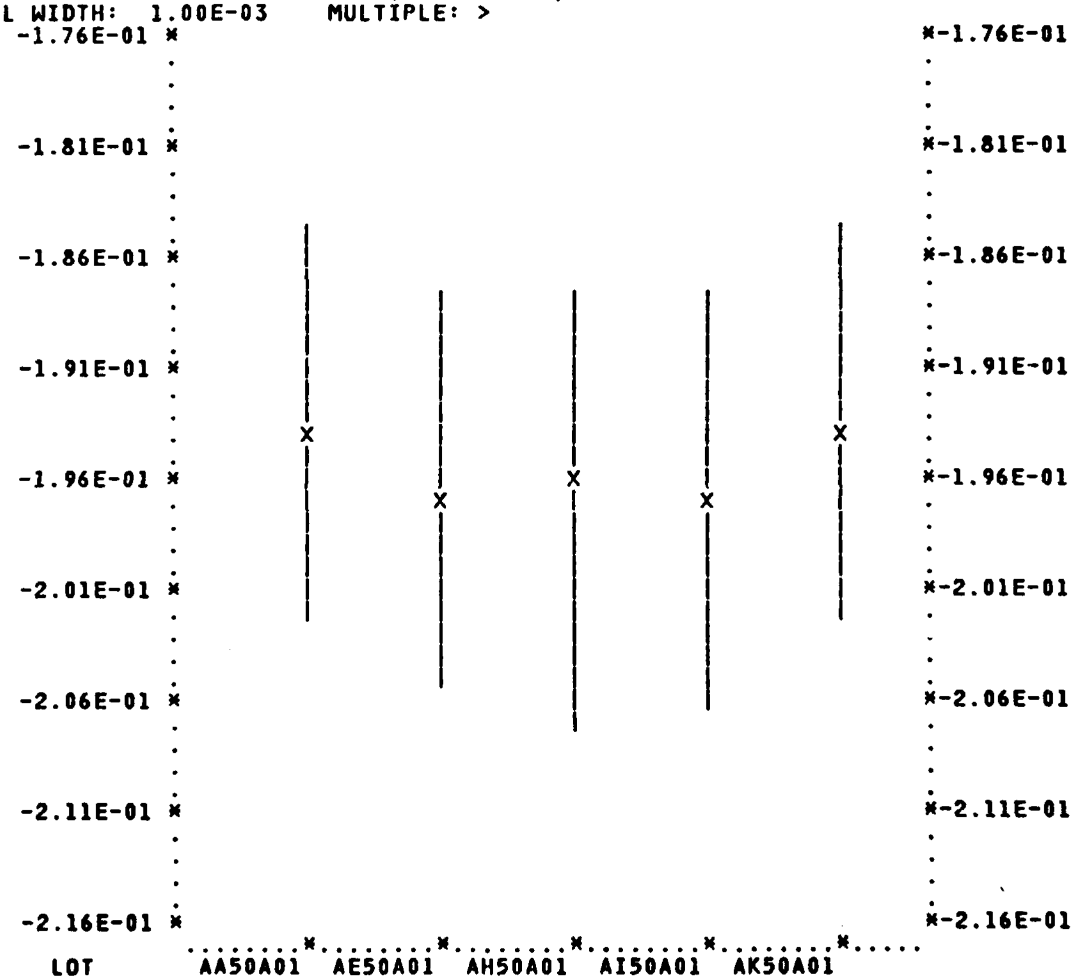

Fig. IV-13 - Trend analysis (continued).

DATE PRINTED : 07/18/81 TIME PRINTED : 3.37.18
VIO(T1) VS TIME
TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND
LOT =AA50A01 OR AE50A01 OR AH50A01 OR AI50A01 OR AK50A01
Y=MED OR 17% OR 84%

TREND PLOT FOR: TYPE = CA741
TEST = 47
LEGEND: /MED =X/17% =|/84% =|/
CELL WIDTH: 2.00E-04 MULTIPLE: >

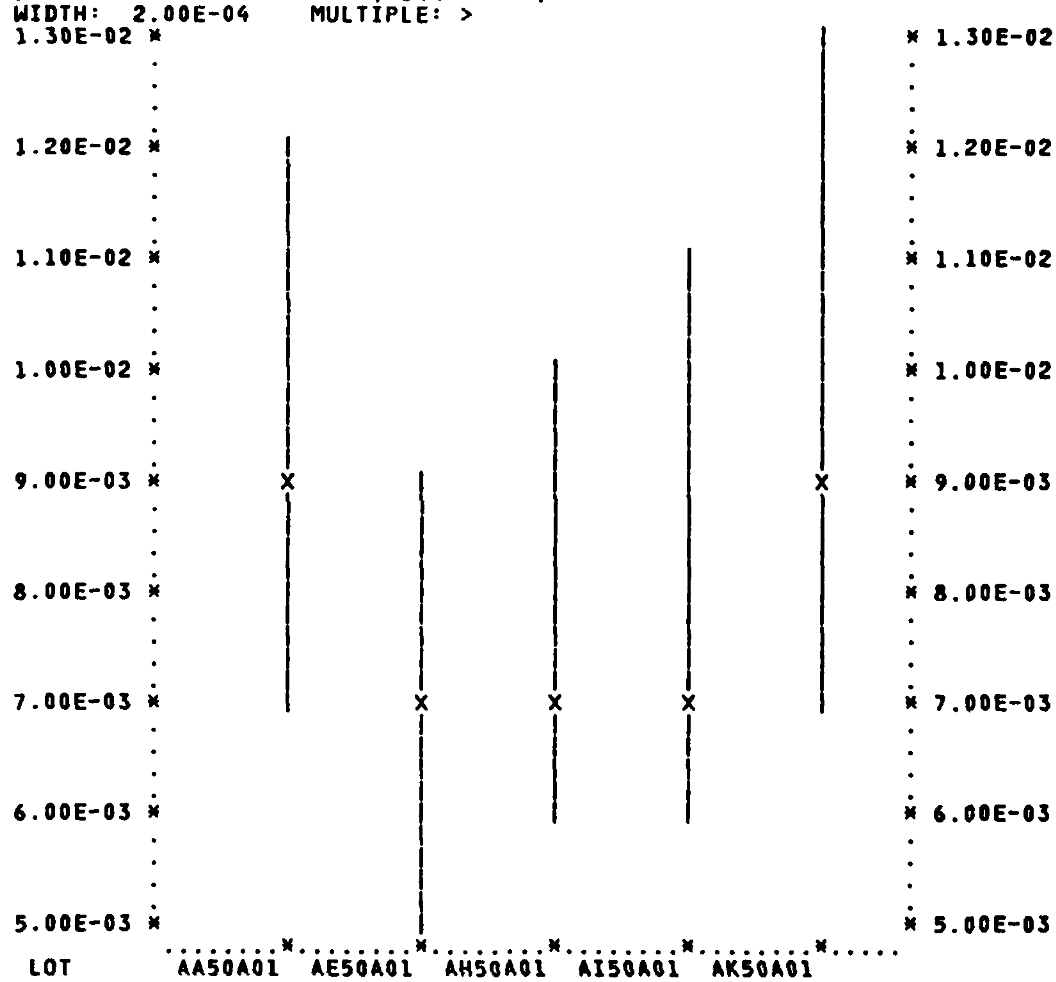

Fig. IV-13 - Trend analysis (continued).

DATE PRINTED : 07/18/81 TIME PRINTED : 3.37.18
VIO(T1) VS TIME
TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND
LOT =AA50A01 OR AE50A01 OR AH50A01 OR AI50A01 OR AK50A01
Y=MED OR 17% OR 84%

TREND PLOT FOR: TYPE = CA741
TEST = 48
LEGEND: /MED =X/17% =|/84% =|/
CELL WIDTH: 2.00E-04 MULTIPLE: >

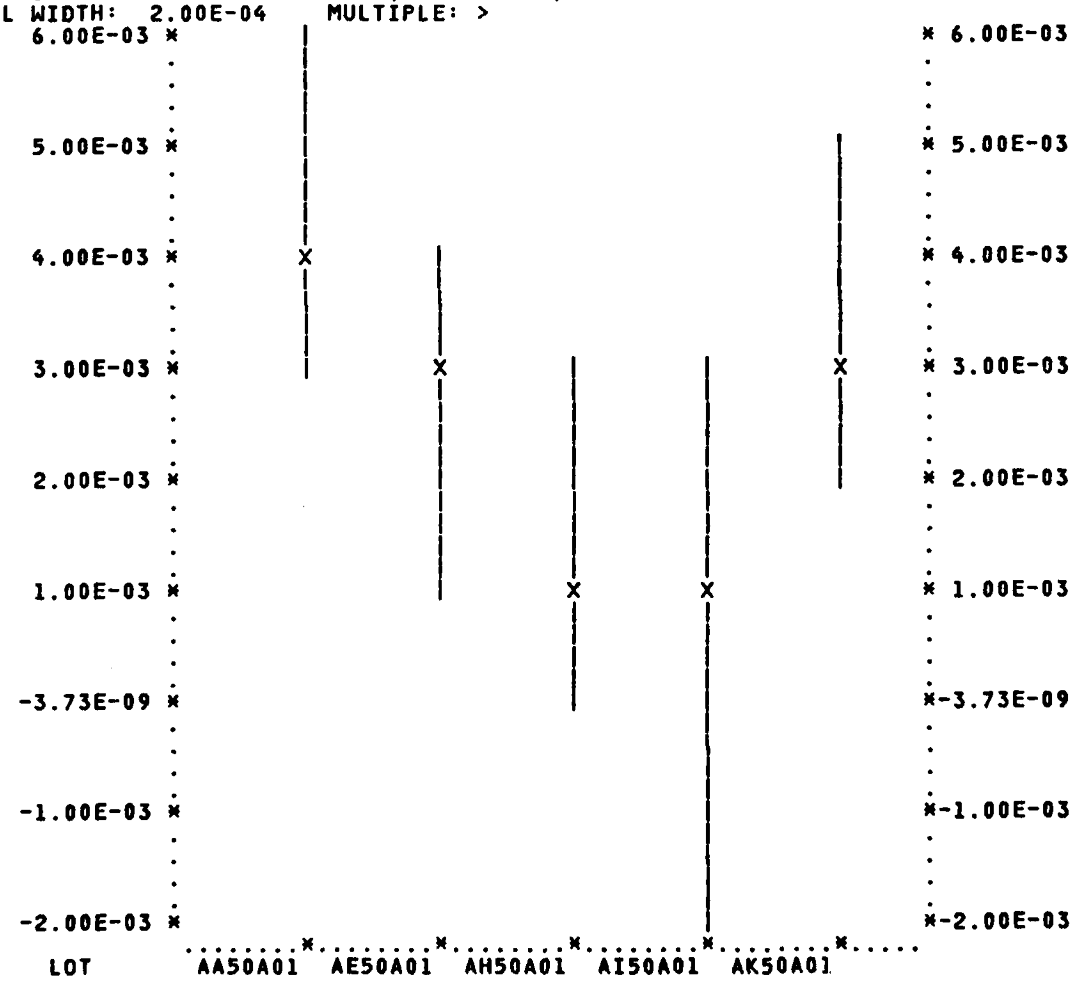

Fig. IV-13 - Trend analysis (continued).

DATE PRINTED : 07/18/81 TIME PRINTED : 3.37.18
VIO(T1) VS TIME
TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND
LOT =AA50A01 OR AE50A01 OR AH50A01 OR AI50A01 OR AK50A01
Y=MED OR 17% OR 84%

TREND PLOT FOR: TYPE = CA741
TEST = 59
LEGEND: /MED =X/17% =|/84% =|/
CELL WIDTH: 1.00E-03 MULTIPLE: >

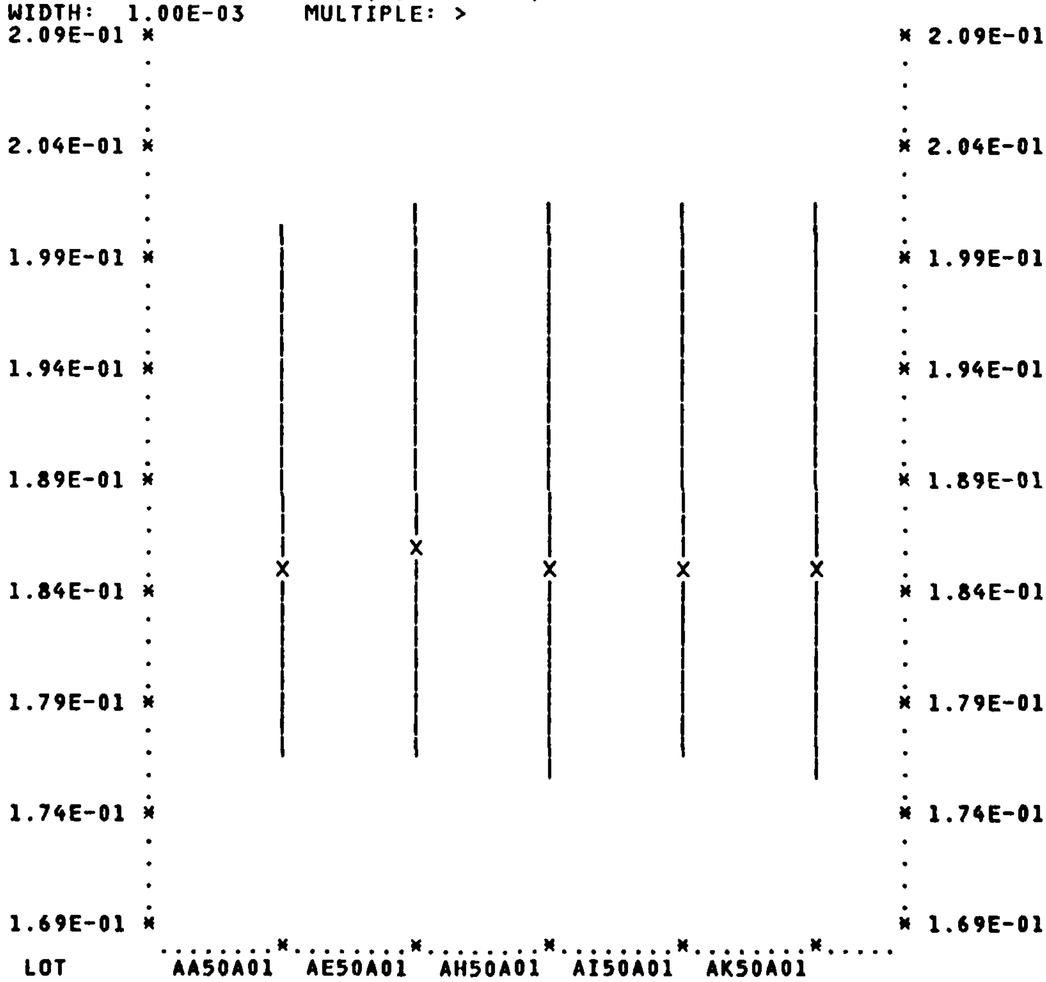

Fig. IV-13 - Trend analysis (continued).

```
DATE PRINTED : 07/18/81                              TIME PRINTED : 3.37.18
VIO(T1) VS TIME
TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND
LOT  =AA50A01 OR AE50A01 OR AH50A01 OR AI50A01 OR AK50A01
    Y=MED OR 17% OR 84%

TREND PLOT FOR: TYPE    = CA741
                TEST    =     60
LEGEND: /MED     =X/17%     =|/84%     =|/
CELL WIDTH:  1.00E-03    MULTIPLE: >
```

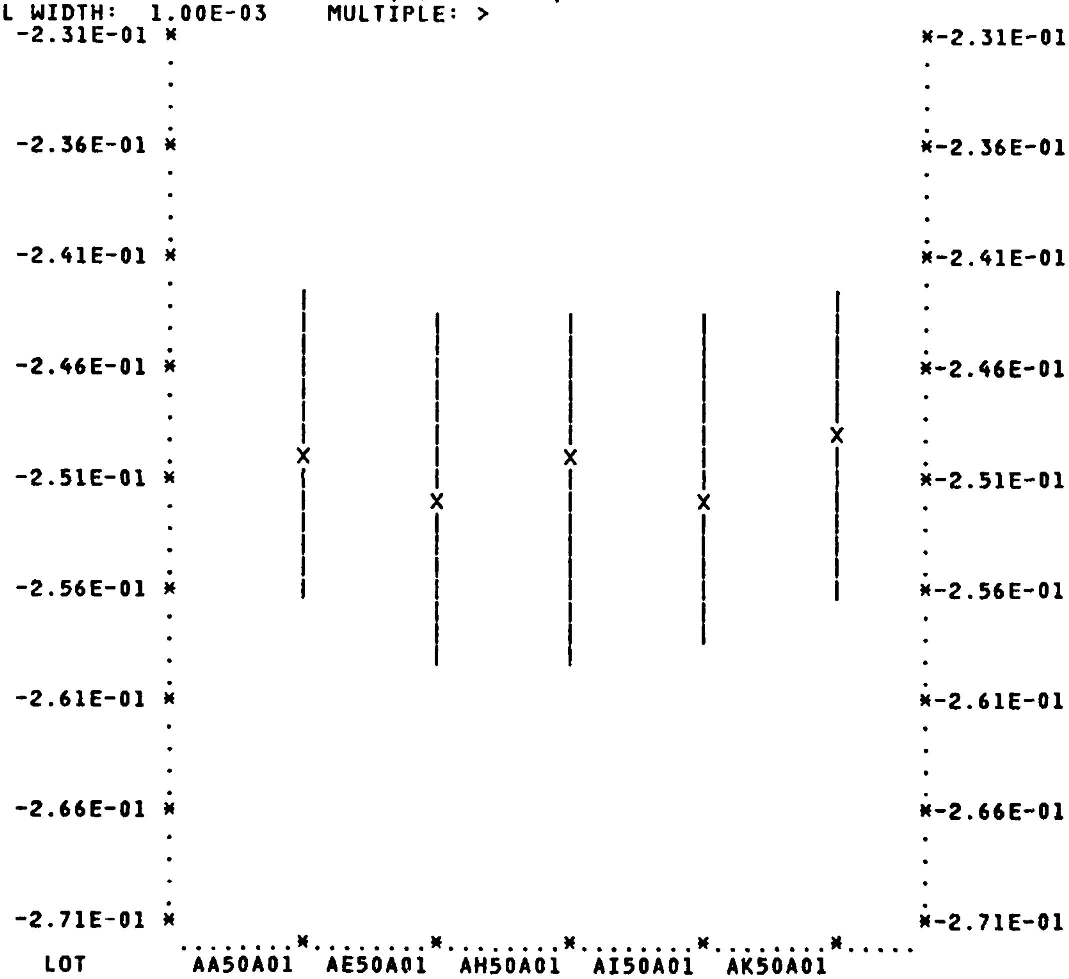

Fig. IV-13 - Trend analysis (continued).

```
DATE PRINTED : 07/18/81                              TIME PRINTED : 3.37.18
VIO(T1) VS TIME
TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND
LOT  =AA50A01 OR AE50A01 OR AH50A01 OR AI50A01 OR AK50A01
    Y=MED OR 17% OR 84%

TREND PLOT FOR: TYPE     = CA741
                TEST     =      61
LEGEND: /MED     =X/17%     =|/84%     =|/
CELL WIDTH:  2.00E-04    MULTIPLE: >
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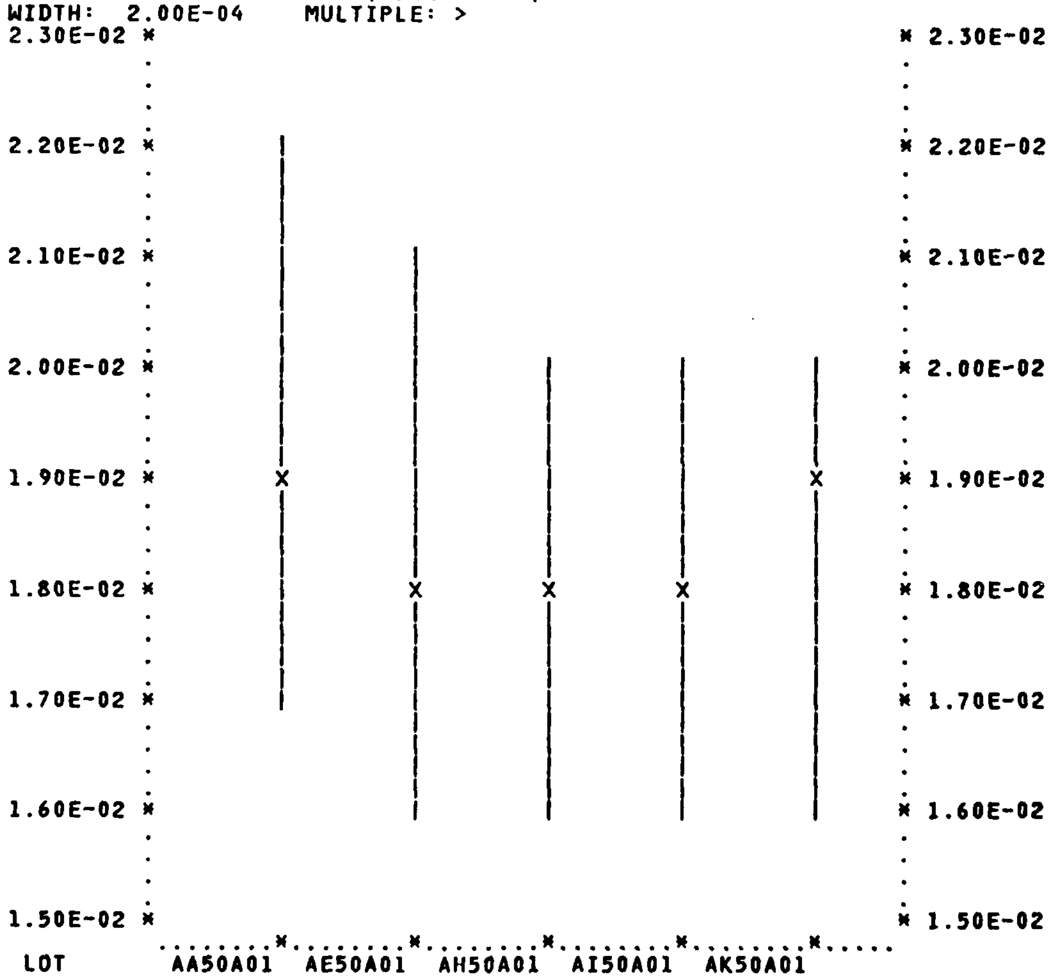

Fig. IV-13 - Trend analysis (continued).

DATE PRINTED : 07/18/81 TIME PRINTED : 3.37.18
VIO(T1) VS TIME
TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND
LOT =AA50A01 OR AE50A01 OR AH50A01 OR AI50A01 OR AK50A01
Y=MED OR 17% OR 84%

TREND PLOT FOR: TYPE = CA741
TEST = 62
LEGEND: /MED =X/17% =|/84% =|/
CELL WIDTH: 2.00E-04 MULTIPLE: >

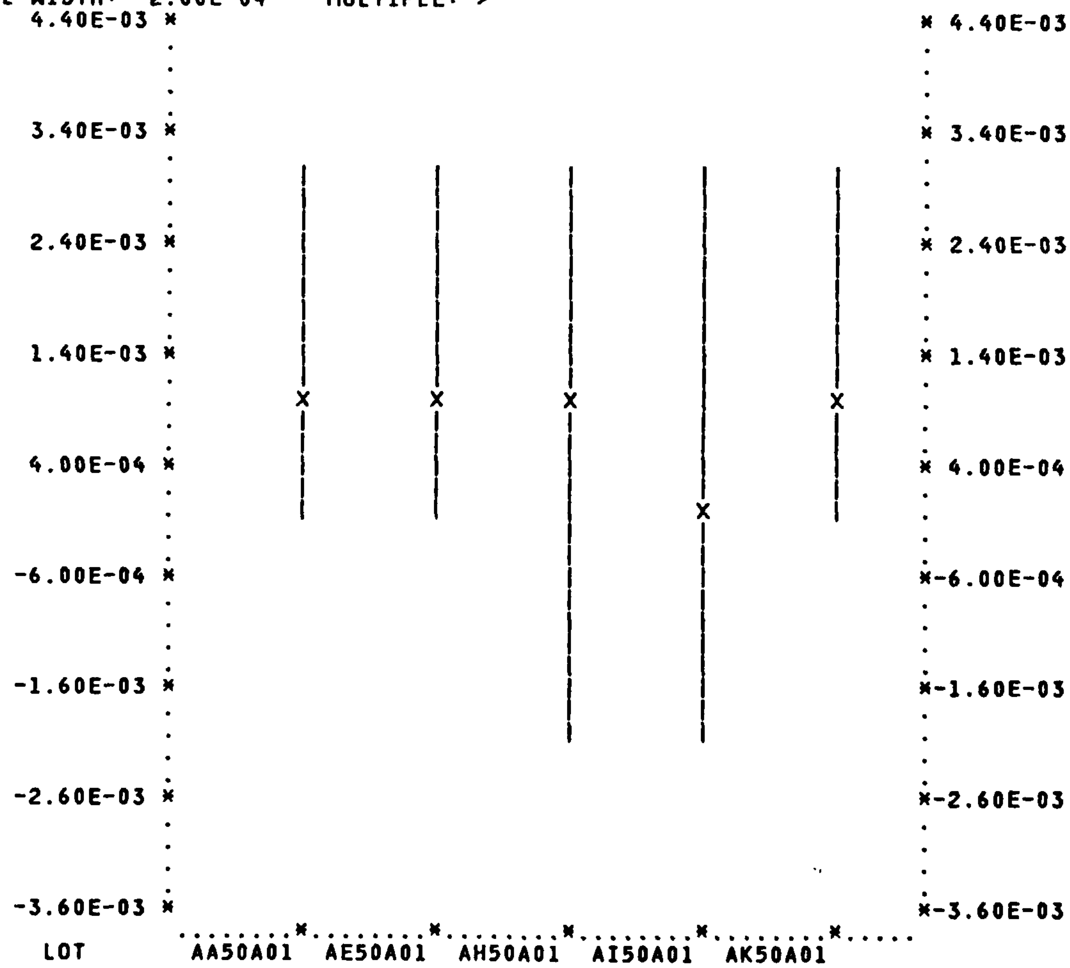

Fig. IV-13 - Trend analysis (continued).

DATE PRINTED : 07/18/81 TIME PRINTED : 3.37.18
VIO(T1) VS TIME
TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND
LOT =AA50A01 OR AE50A01 OR AH50A01 OR AI50A01 OR AK50A01
Y=MED OR 17% OR 84%

TREND PLOT FOR: TYPE = CA741
TEST = 70
LEGEND: /MED =X/17% =|/84% =|/
CELL WIDTH: 1.00E-04 MULTIPLE: >

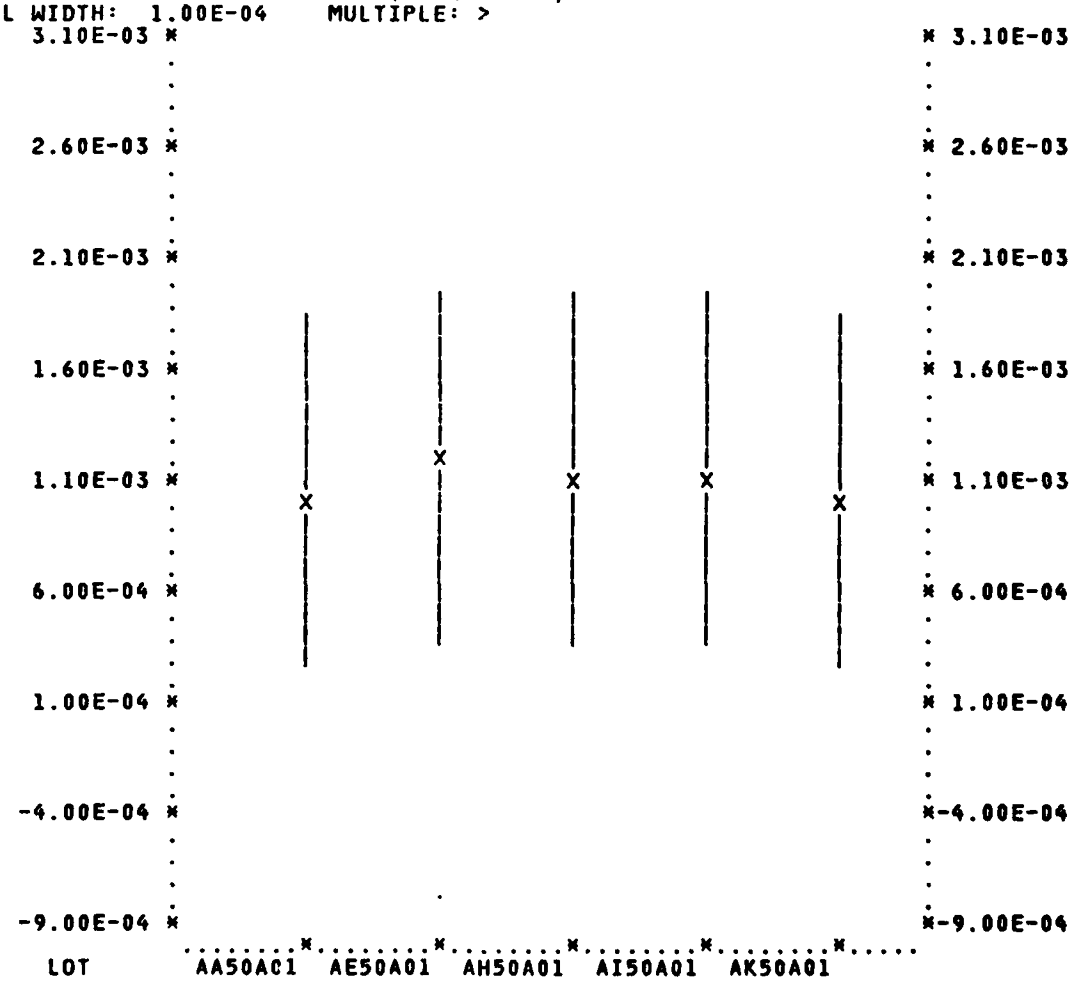

Fig. IV-13 - Trend analysis (continued).

```
DATE PRINTED : 07/18/81                        TIME PRINTED : 3.37.18
VIO(T1) VS TIME
TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND
LOT  =AA50A01 OR AE50A01 OR AH50A01 OR AI50A01 OR AK50A01
    Y=MED OR 17% OR 84%

TREND PLOT FOR: TYPE    = CA741
                TEST    =      71
LEGEND: /MED     =X/17%     =|/84%     =|/
CELL WIDTH:  1.00E-03    MULTIPLE: >
```

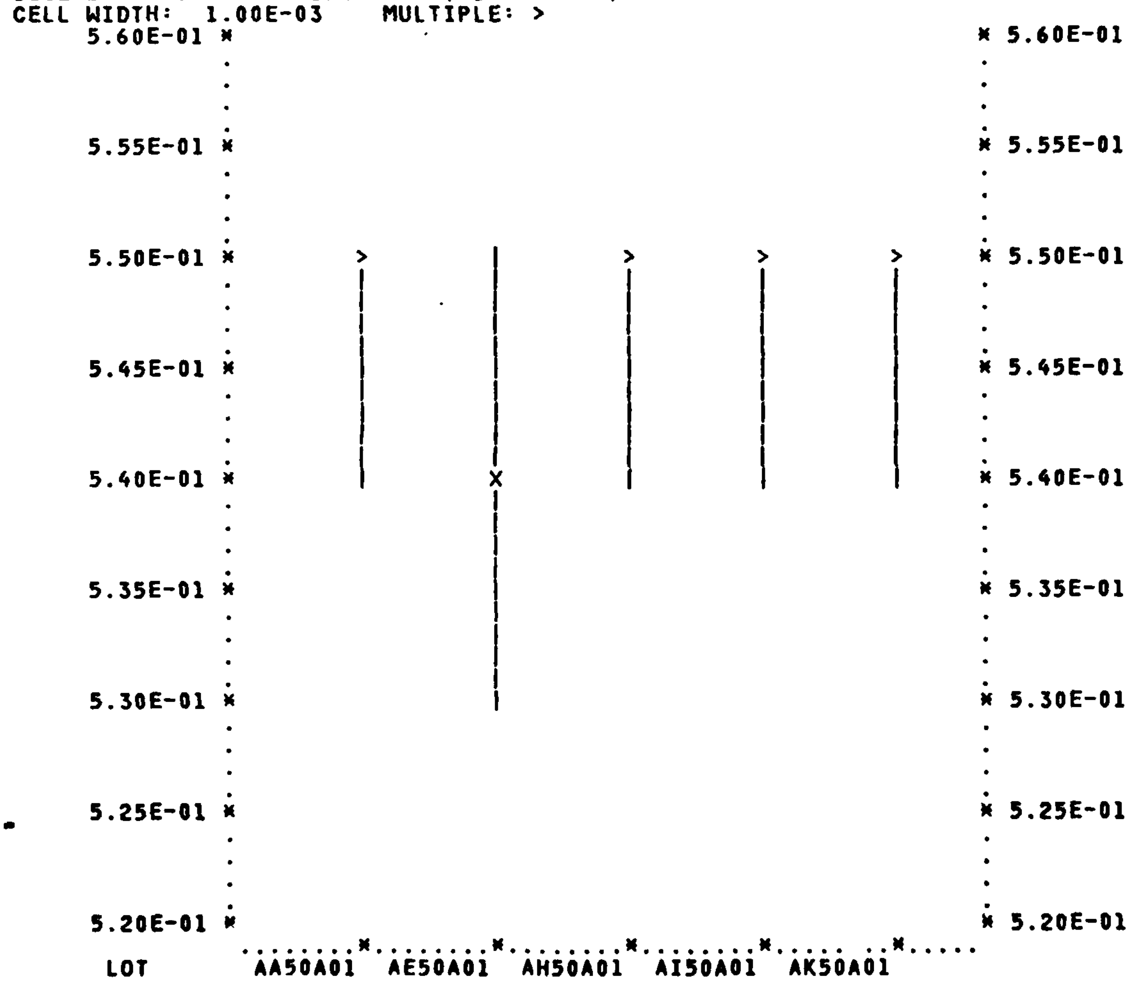

Fig. IV-13 - Trend analysis (continued).

DATE PRINTED : 07/18/81 TIME PRINTED : 3.37.18
VIO(T1) VS TIME
TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND
LOT =AA50A01 OR AE50A01 OR AH50A01 OR AI50A01 OR AK50A01
Y=MED OR 17% OR 84%

TREND PLOT FOR: TYPE = CA741
TEST = 72
LEGEND: /MED =X/17% =|/84% =|/
CELL WIDTH: 1.00E-03 MULTIPLE: >

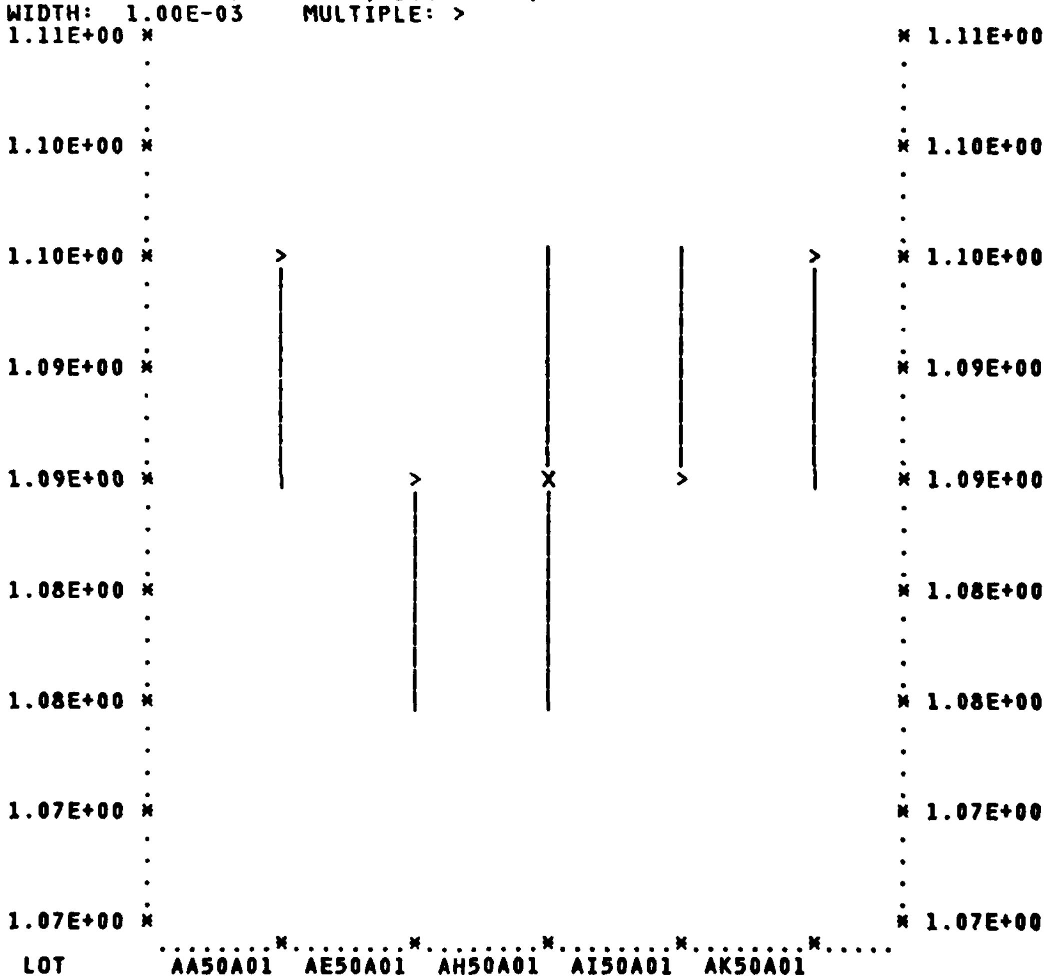

Fig. IV-13 - Trend analysis (continued).

DATE PRINTED : 07/18/81 TIME PRINTED : 3.37.18
VIO(T1) VS TIME
TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND
LOT =AA50A01 OR AE50A01 OR AH50A01 OR AI50A01 OR AK50A01
Y=MED OR 17% OR 84%

TREND PLOT FOR: TYPE = CA741
TEST = 93
LEGEND: /MED =X/17% =|/84% =|/
CELL WIDTH: 2.00E-09 MULTIPLE: >

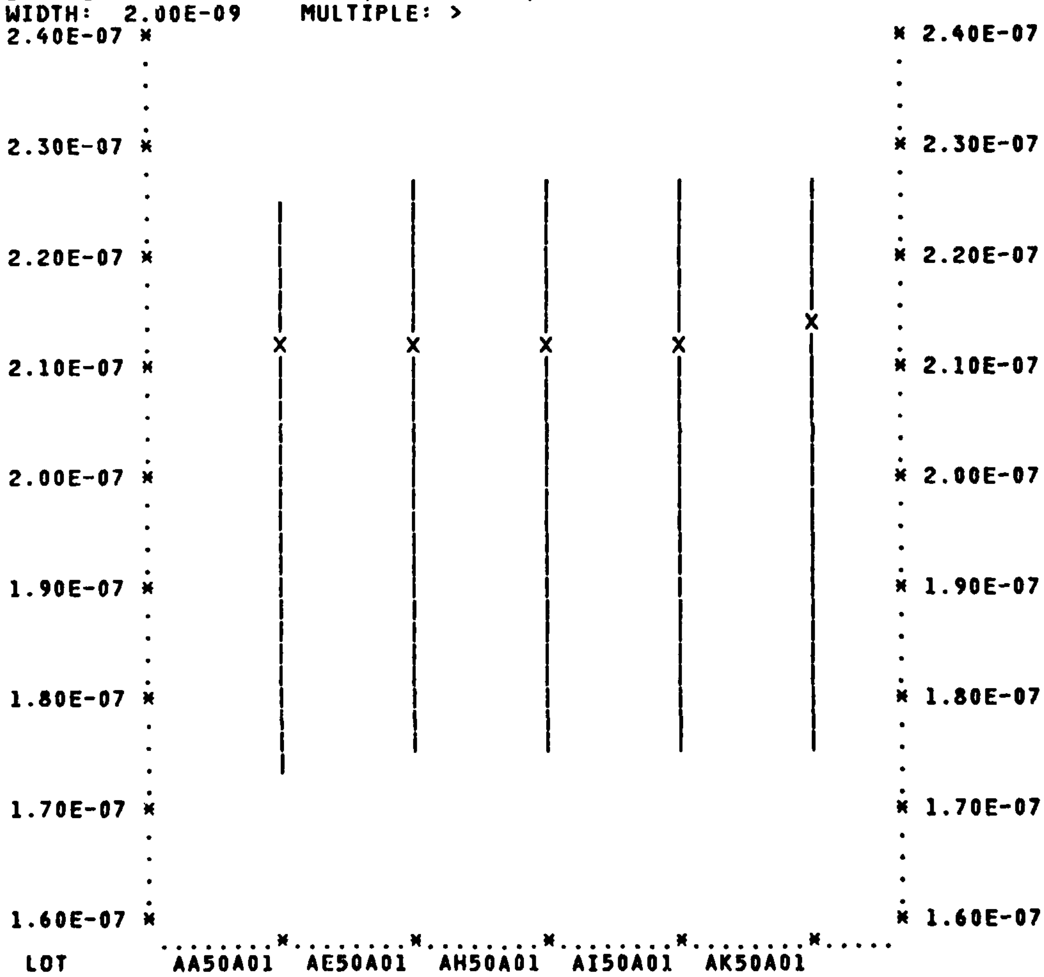

Fig. IV-13 - Trend analysis (continued).

DATE PRINTED : 07/18/81 TIME PRINTED : 3.37.18
VIO(T1) VS TIME
TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND
LOT =AA50A01 OR AE50A01 OR AH50A01 OR AI50A01 OR AK50A01
Y=MED OR 17% OR 84%

TREND PLOT FOR: TYPE = CA741
TEST = 94
LEGEND: /MED =X/17% =|/84% =|/
CELL WIDTH: 2.00E-01 MULTIPLE: >

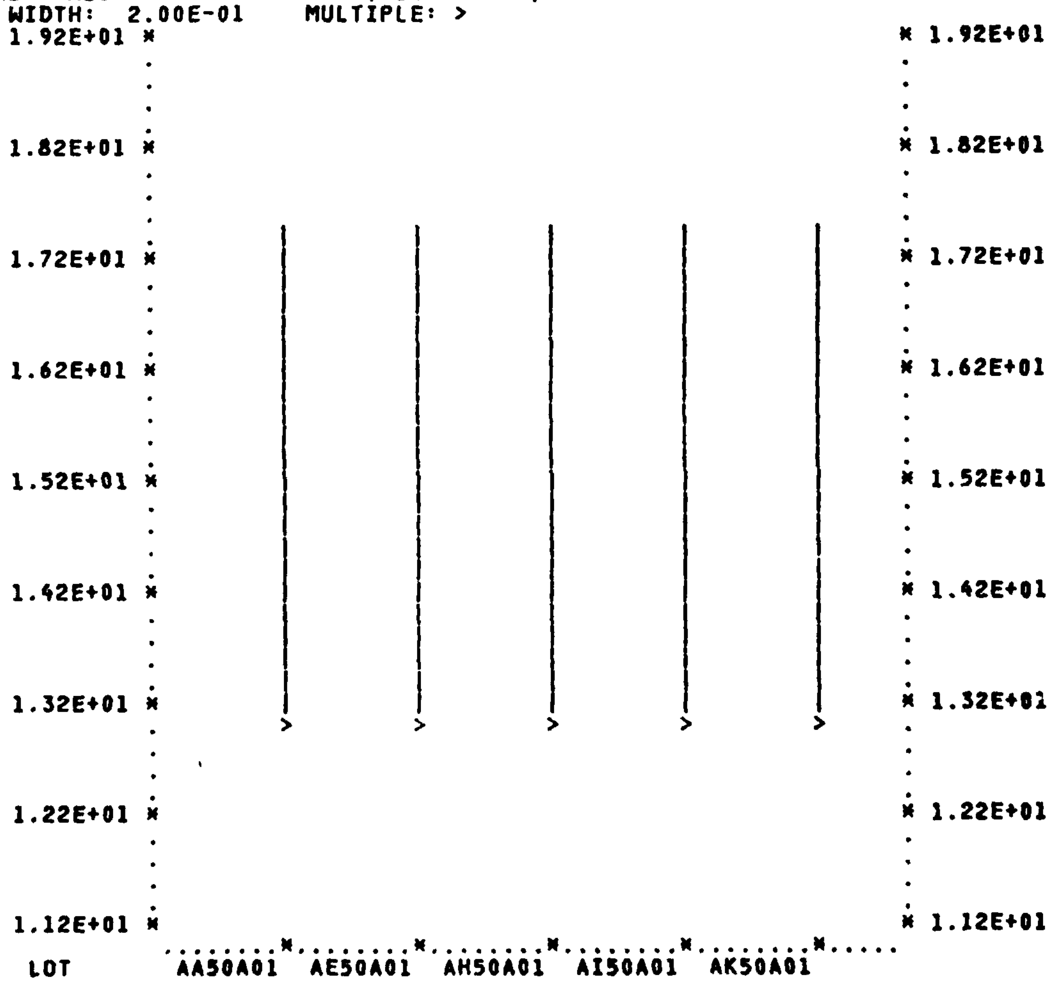

Fig. IV-13 - Trend analysis (continued).

```
DATE PRINTED : 07/18/81                              TIME PRINTED : 3.37.18
VIO(T1) VS TIME
TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTR
LOT  =AA50A01 OR AE50A01 OR AH50A01 OR AI50[illegible] OR AK50A01
    Y=MED OR 17% OR 84%

TREND PLOT FOR: TYPE     = CA741
                TEST     =      95
LEGEND: /MED      =X/17%      =|/84%      =|/
CELL WIDTH:  4.00E-08    MULTIPLE: >
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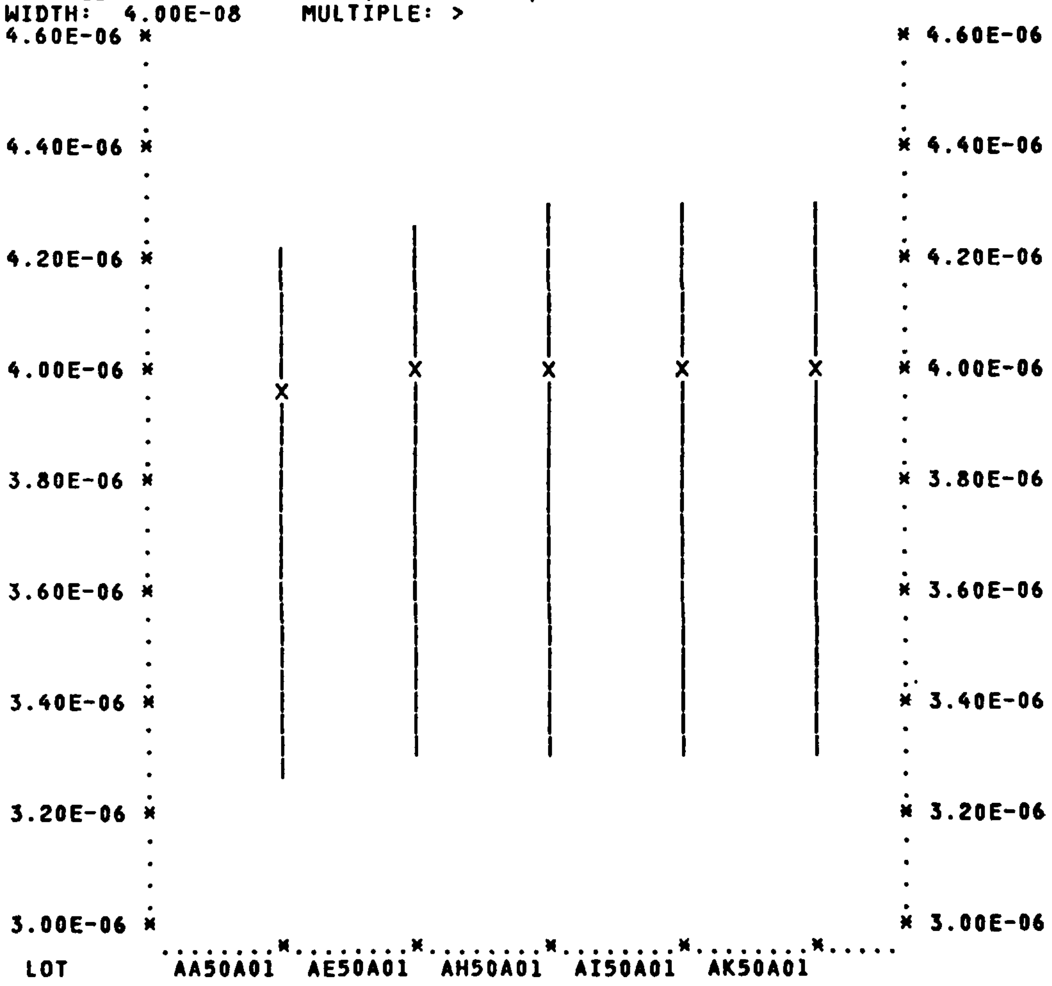

Fig. IV-13 - Trend analysis (continued).

DATE PRINTED : 07/18/81   TIME PRINTED : 3.37.18
VIO(T1) VS TIME
TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND
LOT =AA50A01 OR AE50A01 OR AH50A01 OR AI50A01 OR AK50A01
Y=MED OR 17% OR 84%

TREND PLOT FOR: TYPE = CA741
TEST = 96
LEGEND: /MED =X/17% =|/84% =|/
CELL WIDTH: 1.00E-07 MULTIPLE: >

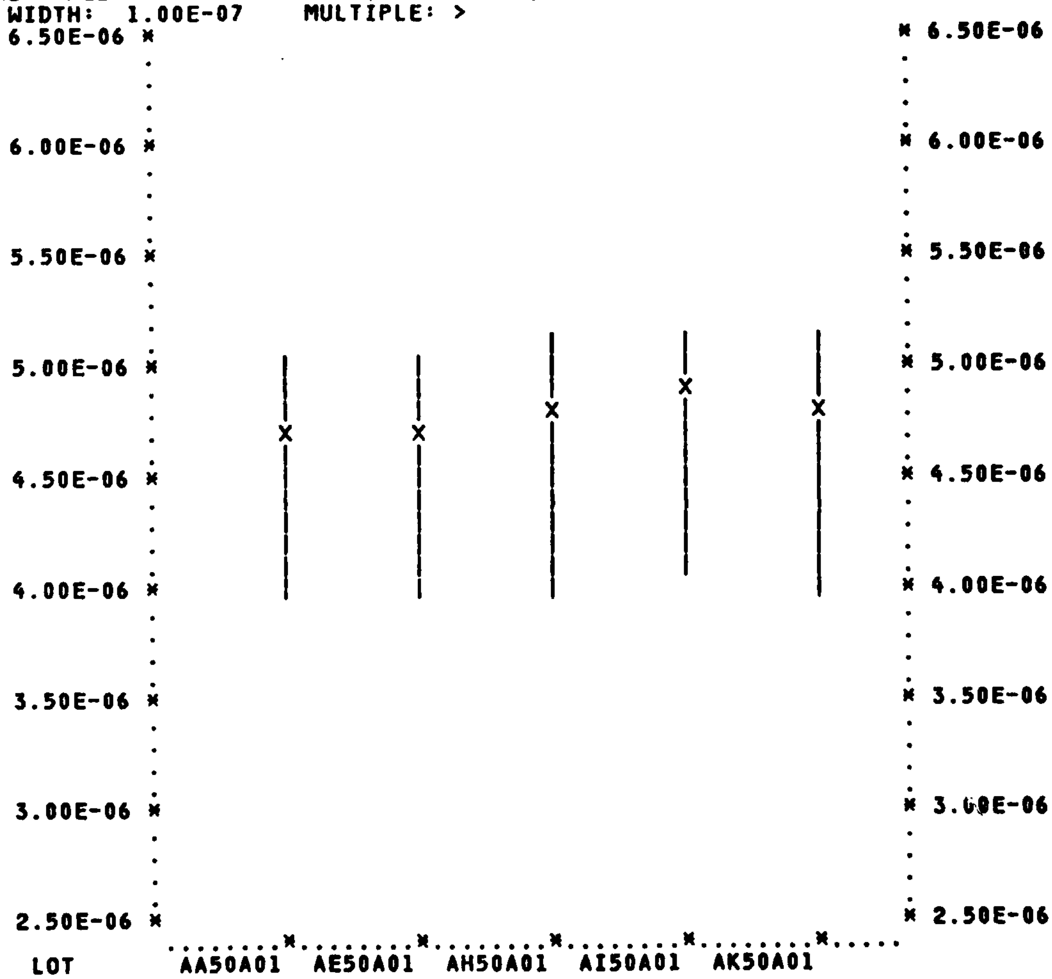

Fig. IV-13 - Trend analysis (continued).

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